R. S.

THE

RAY SOCIETY.

INSTITUTED MDCCCXLIV.

This volume is issued to the Subscribers to the RAY SOCIETY *for the Year* 1905.

LONDON:

MDCCCCV.

THE BRITISH FRESHWATER RHIZOPODA AND HELIOZOA

BY

JAMES CASH

ASSISTED BY

JOHN HOPKINSON, F.L.S., F.R.M.S., ETC.

Secretary of the Ray Society

VOLUME I

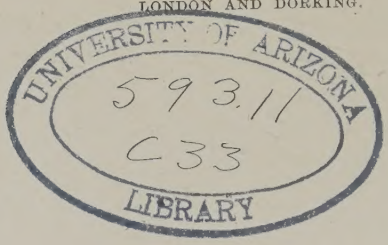
RHIZOPODA, PART I

LONDON

PRINTED FOR THE RAY SOCIETY

1905

PRINTED BY ADLARD AND SON,
LONDON AND DORKING.



PREFACE.

The main object in the preparation of this work was to bring together, as concisely and accurately as possible, in a single manual, all that has been so far discovered regarding the British Freshwater Rhizopoda and their near allies the Heliozoa. The labours of Dr. Penard of Geneva have resulted in his giving to the world exceedingly valuable monographs of the Rhizopoda and Heliozoa of Central Europe, and of Switzerland in particular; and it is to be regretted that no British Biologist of equal standing has done the same for this country, which is certainly not less rich in species.

The present attempt at a classified description of these microscopic animals will it is hoped lead to other workers entering upon a field of research which is fascinating in a high degree even to the general microscopist. The biological student will find in this manual an honest effort, at least, to describe the species which have hitherto been met with in this country, to give their usual habitats, and to point out the characters by which they may be most easily identified.

I do not profess to have investigated very closely the physiological problems associated with the life-histories of these organisms; the minute and continuous observations which are necessary for that

59101

can scarcely be undertaken by one possessing only occasional opportunities for their study; but this monograph it is hoped will help to show that a large amount of inviting material lies ready to the hand of the earnest student.

The field is a wide one. Besides the structural beauty of the Rhizopoda and the interesting phases of their life-histories, the possibilities open to anyone of discovering new and previously unsuspected forms in our ponds and marshes, are practically unlimited.

Whilst holding myself responsible for all microscopic and descriptive work in the preparation of this monograph, I desire to express my indebtedness to Mr. John Hopkinson for the assistance which he has rendered to me, particularly in working out the synonymy of the genera and species described. This has entailed upon him an expenditure of time and labour which cannot be too generously acknowledged. Mr. Hopkinson has in preparation a Bibliography of the Freshwater Rhizopoda and Heliozoa which will appear in a future volume of this work.

To him I am also indebted for the suggestion of the term Conchulina as applicable to the shelled freshwater Rhizopoda. The discarded "Testacea"—a term pre-occupied in the Mollusca—is unsuitable, and its continued use is undesirable. Conchulina, besides being strictly accurate, is also especially appropriate to these minute organisms.

JAMES CASH.

Sale, Manchester,
27*th October*, 1905.

CONTENTS OF VOL. I.

	PAGE
Introduction	1
Classification	34
Class Sarcodina. Sub-class Rhizopoda	39
Order I. Amœbina	39
Family 1. Lobosa	39
Genus 1. Amœba	40
2. Dactylosphærium	64
3. Mastigamœba	69
4. Pelomyxa	73
5. Lithamœba	81
6. Ouramœba	83
Family 2. Reticulosa	85
Genus 7. Gymnophrys	86
8. Biomyxa	88
9. Penardia	89
10. Chlamydomyxa	91, 140
Family 3. Vampyrellida	94
Genus 11. Vampyrella	95
12. Hyalodiscus	106
13. Nuclearia	109
14. Archerina	112
Order II. Conchulina	115
Family 1. Arcellida	115
Genus 15. Arcella	117, 138
16. Pseudochlamys	129
17. Centropyxis	131
Index of Species, etc., described	146

LIST OF THE PLATES.

PLATE

I.—Figs. 1–6.—*Amœba proteus.* Figs. 7–10.—*A. actinophora.*

II.—*Amœba villosa.*

III.—Fig. 1.—*Amœba limax.* Fig. 2.—*A. proteus.* Figs. 3–5.—*A. gorgonia.* Figs. 6, 7.—*A. striata.* Figs. 8–11.—*Dactylosphærium radiosum.* Fig. 12.—*D. polypodium.*

IV.—Figs. 1–5.—*Amœba pilosa.* Figs. 6–11.—*Dactylosphærium radiosum.* Fig. 12.—*D. polypodium.*

V.—Figs. 1–3.—*Amœba verrucosa.* Fig. 4.—*A. guttuta.* Fig. 5.—*Lithamœba discus.* Fig. 6.—*Ouramœba vorax.*

VI.—Figs. 1–5.—*Mastigamœba aspera.* Fig. 6.—*M. ramulosa.*

VII.—Figs. 1–3.—*Pelomyxa palustris.* Figs. 4–6.—*P. villosa.*

VIII.—Figs. 1, 2.—*Gymnophrys cometa.* Figs. 3, 4.—*Biomyxa vagans.*

IX.—*Penardia mutabilis.*

X.—*Vampyrella lateritia.*

XI.—Figs. 1–3.—*Vampyrella lateritia.* Figs. 4–6.—*V. vorax.* Figs. 7–12.—*V. flabellata.* Figs. 13–15.—*V. gomphonematis.*

XII.—*Nuclearia delicatula.*

XIII.—Fig. 1.—*Nuclearia conspicua.* Figs. 2–11.—*Hyalodiscus rubicundus.*

XIV.—Fig. 1.—*Chlamydomyxa labyrinthuloides.* Figs. 2–6. *Archerina Boltoni.*

XV.—Figs. 1–3, 11–17.—*Arcella vulgaris.* Figs. 4–6.—*A. discoides.* Figs. 7, 8.—*A. dentata.* Figs. 9, 10.—*A. mitrata.*

XVI.—Figs. 1–9.—*Pseudochlamys patella.* Figs. 10–16.—*Centropyxis aculeata.*

ILLUSTRATIONS IN THE TEXT.

FIGS.		PAGE
1.	*Pelomyxa palustris :* portion of periphery	6
2.	*Amœba proteus :* pseudopodia	10
3.	*Lithamœba discus :* pseudopodium	10
4.	*Biomyxa vagans :* pseudopodia	11
5.	*Amœba proteus :* diagram of pseudopodium	12
6–9.	„ „ contraction of vacuole	13
7.	*Hyalosphenia papilio :* test	17
8.	*Difflugia pyriformis :* test	17
9.	*Sphenoderia fissirostris :* test	18
10.	*Quadrula symmetrica :* test	18
11.	*Trinema enchelis :* test	18
12.	*Microgromia socialis :* reproduction	24
13.	*Difflugia pyriformis :* conjugation	25
14.	*Nebela collaris :* conjugation	25
15.	*Amœba proteus :* dissolution	29
16.	*A. limicola*	56
17, 18.	*Arcella vulgaris :* test	120
19.	„ „ var. *gibbosa*	120
20.	*A. discoides*	123
21–23.	*A. dentata*	127
24, 25.	*A. artocrea*	128
26.	*Centropyxis aculeata* var. *spinosa*	135
27.	*C. lævigata*	137
28.	*Arcella vulgaris* var. *compressa*	139
29.	*Chlamydomyxa montana :* active state	141
30.	*C. montana :* pseudopodal filaments	143
31.	„ „ fragment of body	143
32.	„ „ encisted state	145

All measurements, except when quoted from other authorities, are expressed in micromillimetres (μ). $1\ \mu = 0{\cdot}001$ mm. or 0·00003937 ($\frac{1}{25400}$) of an inch.

BRITISH
FRESHWATER RHIZOPODA.

INTRODUCTION.

The Rhizopoda are animals of minute size and rudimentary structure, forming, with the Heliozoa and Radiolaria, the class Sarcodina of Bütschli. The term Rhizopoda—literally meaning "root-footed"—now almost universally adopted, was invented by the French naturalist Dujardin to distinguish "animals provided with variable processes."

The Sarcodina, with the Mastigophora (flagellate animals), the Sporozoa (a group of endo-parasites), and the Infusoria, make up the sub-kingdom of the Protozoa, which is represented by some 1600 genera and many thousands of species.

For present purposes we are not concerned with the Mastigophora as a group (though, as will be seen later, they bear some relationship with the lobose Rhizopods), nor yet with the Infusoria or the Sporozoa. The Radiolaria, also, are excluded from consideration by the fact that they are marine; they possess ray-like pseudopodia resembling those of the Heliozoa, but differ from animals of that sub-class in having a comparatively large "central capsule," which is membranous, minutely perforated, and marked, usually, by lines which divide its surface into polygonal segments.

The whole of the Protozoa are microscopic creatures. Their existence was not even suspected until

Leeuwenhoek (*circa* 1675), with his simple lenses, began to examine drops of pond-water, and discovered some of the commoner ciliated forms. Continued observation by this naturalist and his contemporaries revealed a variety of life-forms; and for many years their origin, organization, and functions were matters of lively controversy. The theory, at first prevalent, of spontaneous generation, was in process of time abandoned; but even so late as the time of Ehrenberg, one of the most assiduous, though not always most accurate, of observers, their unicellular structure, now universally conceded, was doubted. Imagination conceived what the imperfect microscopical appliances of the time failed to reveal, and the impression was formed that they were possessed of organs analogous to those of the Metazoa. Ehrenberg (1838) pictured them with many stomachs, and from that fancied character applied to them the title, now obsolete, of Polygastrica.

The greater perfection and higher powers of modern microscopes have contributed to the elucidation of the structure of the Protozoa and of their life-functions. Structurally they are simple cells, or single corpuscles, of protoplasm. Siebold, Kölliker, and Max Schultze early demonstrated the groundlessness of Ehrenberg's theory. Dujardin, together with Bütschli, Auerbach, Claparède and Lachmann, Hertwig and Lesser, as well as our own countrymen Dr. Wallich, Mr. H. J. Carter, and Mr. William Archer, extended our knowledge of the tribe materially. More recently the physiological relations and classification of the Rhizopoda have been studied, and the results recorded, by Professor Ray Lankester and others, in the pages of the 'Encyclopædia Britannica,' the 'Journal of the Linnean Society,' the 'Quarterly Journal of Microscopical Science,' and elsewhere. Naturalists abroad have for years worked unceasingly in the same field, and the scientific publications of Germany, Switzerland, Italy, and France, for more than a generation, have afforded evidence of the keen observation of Greeff, Gruber,

Cienkowsky, Verworn, Rhumbler, Blochmann, Penard, Maggi, Cattaneo, and Dangeard; whilst Professor Leidy, by the publication in 1879 of his classic 'Fresh-water Rhizopods of North America,' stimulated observation in this department of zoology in his own country.

Protoplasm and Cell-structure.

The constituent element in the composition of the Rhizopoda is protoplasm, the living matter, as physiology teaches, "from which all animated beings are formed and developed, and to the properties of which all their functions refer." They present no differentiation of tissues or of organs; their bodies are contractile, and for the most part translucent, resembling, as has been aptly said, a tenacious mucus, or soft tremulous jelly; whilst their movements, always slow and erratic, seem aimless, except for the supply of the primary need of an animated being—the acquisition of food.

The Rhizopoda, in common with all primitive life-forms, are unicellular. It is desirable, in order to make clear the significance of this term, to say a few words regarding the structure, etc., of the simple cell.

The cell, physiologically, is a minute vesicle, or closed sac, the enveloping membrane or cell-wall enclosing the protoplasmic substance in which the functional phenomena reside. Of such cells—modified, of course, and more or less differentiated—the bodies of all animals are built up. A recent American writer* thus summarises the ascertained facts in this connection. The protoplasm of an ordinary typical cell in the Metazoa, as well as in the higher plants, is differentiated into cell-body or cytoplasm, and nucleus, of which the difference in chemical composition is considerable. The former is rich in proteids (albumen playing the most important part) and poor in phosphorus. The nucleus, on the other hand, is rich in phosphorus bound up in a substance called nuclein, but poor in albumen.

* Dr. G. N. Calkins, 'The Protozoa' (1901), chap. viii.

The Protoplasmic Body.

The fact that no distinct membranous envelope can be detected in the naked protoplasts (*e.g. Amœba proteus*) does not nullify the assumption of their unicellular nature. Auerbach asserted that such an envelope does, in fact, exist;* but his view has been rejected by later observers. It was strenuously opposed by our countryman Dr. Wallich, whose conclusions, published in 1863, remain unrefuted.† Wallich showed that ectoplasm and endoplasm (terms denoting the outer layer and the more fluid inner substance of the plasma-body) are not "permanent portions of the protean structure, but mutually convertible one into the other, and that it is an essential feature of sarcode that while the outer layer is, for the time being, *ipso facto* instantly differentiated into ectosarc, the same layer reverts to the condition of endosarc."‡ That portion of the plasma-body (referring more particularly to the *Amœbæ*) which is in immediate contact with the surrounding medium acquires a certain density, by coagulation or some process analogous thereto, whilst the central mass, containing granular matter, incepted food, etc., remains semi-fluid.

The same view has more recently been expressed by Prof. Ray Lankester. He maintains that ectoplasm and endoplasm "are not to be understood as distinct layers, but are one and the same continuous substance; what is external at one moment, becoming internal at another; no real structural difference existing between them."

Gruber, as the result of independent observations, and without reference to Wallich's view, arrived at the same conclusion.§ He was definitely and decidedly of

* 'Zeitschr. für Wiss. Zool.,' vii (1856).

† 'Ann. and Mag. Nat. Hist.' (3) xi (1863), pp. 369, 370.

‡ The terms "ectosarc" and "endosarc" are synonymous with ectoplasm and endoplasm. The latter are now in more general use.

§ 'Biologischer Centralblatt,' vi (1886).

opinion "that no division of the Rhizopod body into zones, sharply differentiated morphologically and physiologically, occurs, and that the interpretations which have been made in this sense are decidedly founded upon illusions." His remarks had reference more especially to the publications of two authors, one of whom, Maggi,* had asserted the existence, not only of an endoplasm and an ectoplasm, but also of a "metoplasm," in which he supposed were seated the secretory organs of the Rhizopod, namely, the contractile vacuoles, whilst the ectoplasm served for locomotion and the endoplasm for digestion. The other, Brass, went somewhat further. He professed to distinguish within the Rhizopod body, and, indeed, in the Infusoria generally, as well as in the animal cell, four kinds of plasma, namely (proceeding from within outwards) the nutritive plasma, the food-plasma, the respiratory plasma, and the motor-plasma. These views had already been refuted by Bütschli† so far as they related to the Infusoria, and Gruber considered that Bütschli's objections applied equally to Brass's work, so far as it bore on the Rhizopoda. "Whoever," he remarked, "has long busied himself with the study of the Rhizopoda, knows how many species there are, especially among the *Amœbæ*, in which, during life, no division into separate zones occurs; in which the whole of the contents of the bodies, as well as the nucleus and vacuoles, are irregularly whirled about, so that, for example, the nucleus (or the nuclei) may be at one time pushed to the extreme periphery, and then again flow back into the centre of the body. If in such Rhizopoda, after the application of reagents, an apparent separation into different plasma-layers occurs, these may be definitely regarded as artificially produced, in face of the conviction arrived at during the life of the animal."

Gruber supports his view by a reference to *Pelomyxa*

* 'Atti Soc. Ital. Sci. Nat.,' xix, fasc. 4 (1876).

† 'Morphol. Jahrb.,' xi (1886).

and certain of the *Amœbæ*, in which often no ectoplasm can be distinguished. Under certain circumstances even here, "such a hyaline external plasma-layer makes its appearance, and this consequently must have been produced from the granular plasma in the way in which, locally bounded, a hyaline pseudopodium is evolved from the body of a Rhizopod consisting of granular plasma." Concerning the external limitations of the Rhizopod body, he says that it is naked, "but it would appear that by contact with water," as Dr. Wallich had previously shown, "a stiffening of the plasma takes place at the periphery, preventing its

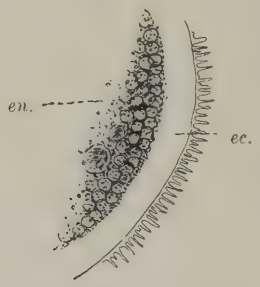


Fig. 1.—Portion of the periphery of *Pelomyxa palustris* when at rest, with the endoplasm (*en*) and ectoplasm (*ec*) sharply defined as frequently seen, and an outer fringe of minute projections from the latter. × about 150.

deliquescence, and also causing an immediate closure of the cut surface, in case of artificial division. When the protoplasm issues forth in a broad process, in the form of pseudopodia, the former bounded portion dissolves in the advancing plasma, to become re-formed at the same moment."

This author acknowledges the prior claim of Dr. Wallich to the discovery. Dr. Wallich was also the first to explain the production of the nutritive vacuoles, by assuming that a drop of water is carried in along with the incepted food-particles, and that this exerts the known stiffening action upon the portions of plasma surrounding the bodies incepted, "so that every nutritive vacuole appears to be lined with an ectosarcal layer."

The conclusions of the authors cited represent, broadly speaking, the present state of our knowledge upon this subject. It may be said to accord with general observation that, so far as there is a regional difference in the plasma-body between endoplasm and ectoplasm, it possesses no morphological significance, but is, as Calkins observes, "only an index of the physical conditions of the protoplasm."*

The Nucleus.

The nucleus plays an important part in the development and functions of the protoplasmic cell. There are certain organisms belonging to the Monera of Hæckel (*e. g. Biomyxa vagans*) in which no nucleus has yet been satisfactorily demonstrated. It does not follow, however, that nuclear substance is absent, for, as Calkins says, nuclei are "almost as varied in the different forms of Sarcodina as are the different types of the animals as a whole."† In some cases where a nucleus is present, it is ill-defined, the chromatin, a part of the nuclear substance stainable with certain basic dyes, being scattered in the form of granules throughout the entire cell. It is possible, this author further says, to conceive of non-nucleated organisms, although the numerous experiments on nucleated and non-nucleated parts of Protozoa show, in these cases at least, the absolute necessity of the nucleus for the life of the individual.

The nuclei observed in different species of Rhizopoda vary in point of number. This is not always uniform in members of the same genus. Usually a single nucleus is present, varying in size and well defined; in certain of the Lobosa and in some Heliozoa there are two or more; in *Pelomyxa palustris*, nuclear bodies, it is asserted, can be counted by the thousand. The testaceous genera (*Arcella*, etc.) are in many cases multinucleated. There may, in some forms, be a mem-

* 'The Protozoa,' p. 38. † *Op. cit.*, p. 86.

brane and a single compact mass of chromatin, which occupies the centre of the distinct nucleus and is separated from the membrane by hyaline matter. In others the chromatin reservoirs may be two or more, or there may be a great number of granules in the nucleus without the reservoirs (*e. g. Amœba proteus*). "In some of the Rhizopoda (*Euglypha*) and Heliozoa (*Actinophrys* and *Actinospherium*), the nucleus is strikingly similar to that of metazoan cells, consisting of chromatin in the form of a reticulum, and a network of linin." *

A true nucleus, comparable to the nuclear structure in Metazoa, according to Hertwig, apparently exists in no case, save possibly in *Actinospherium*, and even here it is limited to a passing phase during cell-division. Discussing this subject Calkins remarks on the probability that the structures which have been almost universally, but erroneously, called nucleoli, do not belong at all to this category of nuclear elements, but represent either the functional chromatin which is aggregated into a central mass (*karyosome*) during the quiescent or vegetative period of cell-life, or the intranuclear division-centre.

This author thus summarises the observations of Gruber, Hertwig, Brauer, and others upon the phenomena presented by the nucleus, during mitosis (cell-division), and concludes: "The facts point toward the conclusion that the centre of activity in the division of the protozoan cell, as in Metazoa, resides in a special structure, which, to avoid confusion in terminology, has been called the division-centre. In some cases this structure resembles the astral system of Metozoa, in consisting of an outer spherical mass with radiating processes (astrosphere), and an inner focal granule or granules (centrosome). The evidence further tends to show that the division-centre in Protozoa consists of a specific substance different from the chromatin and from the cytoplasm, and possessing above all other portions of the cell an active *rôle* in division. No con-

* Calkins, *op. cit.*, p. 87.

clusive evidence is forthcoming to show whether this substance is permanent in all cells, and whether it was originally nuclear or cytoplasmic in origin, although the widespread intra-nuclear condition favours the view that it originated there."*

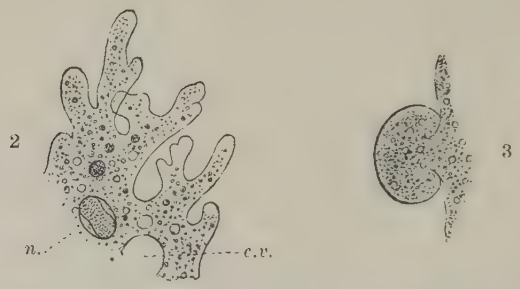
The importance of the nucleus in the economy of all unicellular organisms has been well established. Without it the function of digestion cannot take place. Hofer in 1889, and Verworn later, demonstrated that no digestive fluid is prepared in the cytoplasm when the nucleus is absent. Hofer also held that the slimy secretion by which the common *Amœba* anchors itself before food-taking is never formed by the enucleated portions; and Verworn in 1888 showed that enucleated pieces of *Polystomella* (one of the marine Foraminifera) could not repair or regenerate the lost shell, while nucleated pieces quickly repaired it. The conclusion of this observer was that enucleated protoplasmic masses cease entirely those chemical processes by which products of the normal shell are used or formed. The generalisation may now, Calkins concludes, be made that no secretion takes place in enucleated fragments. On the other hand, the nucleus, by itself—*i. e.* separated from the cytoplasm—has no longer the power to regenerate the lost parts, and like the enucleated cytoplasm, soon dies. Bütschli's conclusion that "the nucleus needs the plasm, the plasm the nucleus," seems well grounded. Their activities are reciprocal. One without the other cannot live. The process of secretion, therefore, whether for the purpose of digestion, or whatever else, in the life of the unicellular organism, is expressed by constant chemical interchange between the cytoplasm and the nucleus.

Means of Locomotion.

Except in a small number of species, the Rhizopoda are endowed with the power of locomotion through

* *Op. cit.*, p. 278.

the agency of pseudopodia. In the Amœbina, Arcellida, and other lobose forms, these "changeable processes" are usually few in number, short, digitate, and blunt at the tip; or they may be broad and lobose—in the *Amœbæ* they are most frequently so—whilst in the *Euglyphæ* and others, included in what Leidy classed as the Filosa, they are acicular, sometimes short, but more frequently of considerable length, and capable of branching, and also, in a small number of forms, of anastomosing. These acicular pseudopodia may be rigid and susceptible of little apparent change for longer or shorter periods; often, however, they change rapidly, or they may whilst fully extended (*e. g.*



Figs. 2 and 3.—Examples of pseudopodia. 2.—Digitate and branching pseudopodia of *Amæba proteus*, showing also nucleus (*n.*) and contractile vacuole (*c.v.*). × about 150. 3.—Eruptive (hernia-like) pseudopodium of *Lithamœba discus*.

Cyphoderia) sway to and fro, bend at an acute angle, or become curved, or take other forms. In some of the Reticularia (Proteomyxa, Ray Lankester) they branch out remarkably, and form a widely-spread network, which, like a spider's web, serves to capture prey. This is conspicuously the case in *Penardia*. The Heliozoa in some cases (probably in most) have radial filaments, the centre of which is occupied throughout its entire length with a thread of "stiffened protoplasm."

In the *Amœbæ* changes of form are sometimes very rapid. The production of pseudopodia, or rather the contributing cause, has been a subject of lively controversy. The theories of the early observers were as

fantastic as they were varied. "Contractile fibres" served for a time to explain the phenomena of motion. Gruber advanced the theory of "pressure from behind." There was, he held, a push forward of the more fluid contents by the posterior ectoplasm, after the extraction of water had given the latter a tougher consistency. The posterior extremity was "drawn into threads as the *Amœba* advances, and the effect of a reversal of the direction of movement, he said, was seen in a flow of ectoplasm from the posterior region, the more tenacious protoplasm appearing then on the opposite side.*

Dr. Wallich disputed Gruber's theory, and reiterated a view which he had long previously expressed, namely,

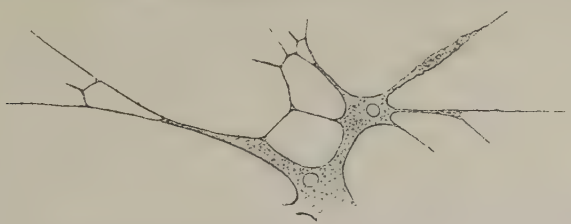


Fig. 4.—Anastomosing pseudopodia of *Biomyxa vagans*. × about 150.

that the rush of granules is not dependent upon any previous contractile effort exercised in the posterior region. The flow merely takes the place of the ectosarc which has been suddenly projected forward. Hence, he argued, the motion is dependent on the contractile power of "the external sarcode layer, and the endosarc only passively participates in it." †

Calkins sums up the controversy by remarking that of late years, especially since Bütschli's masterly work on the structure of protoplasm, there has been a general tendency to abandon the older theory of contractility, and to explain the movements of amœboid bodies through the physical laws of liquids, and in particular the laws of surface-tension. The origin of a pseudo-

* 'Zeitschr. für Wiss. Zool.,' xl (1884).

† 'Ann. and Mag. Nat. Hist.' (5) xvi (1885), p. 215.

podium is clearly in the ectoplasm, and the rapidity of its formation is increased by the peculiar "fountain currents" characteristic of most pseudopodia. As observed by Bütschli, an advancing stream of granules flows through the centre, or axis, of the growing pseudopodium, while near its apex return currents, "like the falling drops of water in a fountain," surround the central stream.* Rhumbler (1898) adduces the hardening effect of water on protoplasm (first suggested by Dr. Wallich) as explaining the formation of new ectoplasm, and the increase in surface of an advancing pseudopodium. The outer ectoplasm has a firm consistence, and as Rhumbler demonstrated by treatment

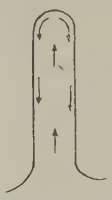


Fig. 5.—Diagrammatic representation of a pseudopodium of *Amœba proteus*. The central arrows represent the forward flow of the endoplasm, the marginal ones the (apparent) "return currents."

with diluted caustic potash—in the case of *Amœba verrucosa*—may be isolated from the endoplasm. Nevertheless, it is converted into streaming endoplasm again. The conversion of ectoplasm into endoplasm, and *vice versâ*, in the activities of the *Amœba*, is a constantly-recurring phenomenon.

But explanations of this nature, as Calkins says, based upon purely physical laws of fluid substances, seem inadequate to explain all types of pseudopodia, the reticulate and long filamentous forms in particular. "Up to the present time," this author remarks, "no satisfactory and comprehensive explanation has been made, and it should be recognized that the theories advanced still remain only working hypotheses."

* The "return currents" are more apparent than real.

The Contractile Vacuole.

The freshwater Rhizopoda, with but few exceptions, exhibit in some part of the plasma at least one contractile vesicle, of which the functions are as yet but imperfectly understood. In the *Amœbæ* it follows the streaming of the endoplasm. In the testaceous forms (*e. g. Arcella*, *Euglypha*) the number of vacuoles varies; they occupy a more definite place in the protoplasm, and are, as a rule, of smaller size.

The action of the vesicle is best seen in the familiar sun-animalcule, *Actinophrys sol*, one of the Heliozoa. It is there situated on the periphery of the body, bulg-

Fig. 6.—Four stages in the contraction of the vacuole in *Amœba proteus*. × about 400. (After Calkins.)

ing outwards conspicuously during diastole, and, if note be taken of the intervals of discharge, the time will be found to approach sixty seconds. The frequency of the pulsations, however, is not the same in all species. The period between diastole and systole is longest in the testaceous forms.

There is considered to be an indefinable relation—actual connection has not been proved—between the contractile vesicle and the nucleus. It is found that, as the vesicle gets filled it falls towards the posterior region by reason of its greater weight as compared with the enclosing endoplasm, and that finally reaching the ectoplasm its contents are discharged outwards. This, however, is not easily demonstrated. Calkins traced the formation and contraction of the vacuole

and the expulsion of the contents, step by step, under a high power. Its reappearance he found to be always somewhere near its point of disappearance. "While still small it is carried along by the streaming protoplasm back to a position near the nucleus, where it completes its development. The increasing weight of the growing vacuole causes it to lag behind the streaming granules and nucleus, until at its full growth it is widely separated from the latter organ. The vacuole may appear to move in the direction contrary to that of the protoplasmic streaming, although in reality it is quiescent; for while it remains in the field of the microscope the main body of the animal moves well out of it, until the vacuole is surrounded only by the posterior end of the animal, which is reduced to a thin layer of granules and a hyaline layer of ectoplasm between the vacuole and the exterior. The granules later move away, passing around the vacuole, until finally there is only a thin layer of hyaline plasm between the vesicle and the exterior. Shortly after this the vacuole bursts and disappears, in most cases a distinct bulge toward the outside preceding contraction. Contraction always begins on one side of the vacuole, and is carried across it toward the outer edge."*

The action of the contractile vesicle, doubtless, has an important physiological meaning. The generally-accepted view is that the periodical discharge is an excretory function. The excess of water in the plasma-body drains into the vacuole, and is thus got rid of. In the more highly-organised Infusoria the water is conveyed to the excretory vacuole by a system of ducts. Such channels have not been seen in the endoplasm of the Rhizopoda; but whatever the means employed by Nature in their case may be, the effect is the same.

Inception of Food.

The food of the Rhizopoda is, in the main, chlorophyllous. It consists of diatoms, desmids, and spores

* Calkins, *op. cit.*, p. 88.

of Algæ. Some species, however, prey upon Rotatoria and other microscopic animals. They seem to have a certain selective power; but this is not universal. It is supposed to be absent from *Amœba* and *Pelomyxa*, which surround with their pseudopodia, and draw in, whatever comes in their way. In certain of the *Vampyrellæ* a power of selection is very pronounced. The Reticularia, according to Verworn, normally take in only living organisms. Some of the Heliozoa—*e. g. Actinosphærium*—capture both infusorians and rotifers, but their staple food, like that of the Rhizopoda in general, is chlorophyll, derived from the sources already mentioned.

In *Amœba proteus*, which may be taken as typical of the order Amœbina, food, of whatever kind, may be incepted at any convenient part of the body-surface. A pseudopodium is directed towards the object encountered—say a diatom—and flowing around it forms a "gastric vacuole." In this the diatom remains until digestion is completed. Finally, the siliceous frustule, deprived of its chlorophyll, is ejected. The chlorophyll, from whatever source derived, is seen rolled into balls or pellets and scattered through the endoplasm, giving to it a more or less green tinge. The water, entering the gastric vacuole along with the food, is believed to change gradually by osmosis with the fluids of the plasm. These contain a digestive acid which reduces the digestible portions of the food probably to some form of peptone, and this, again by osmosis, is then assimilated in all parts of the endoplasm.

A remarkable similarity has been found to exist between the action of the naked Lobosa and certain fluid substances, and upon this some ingenious theories have been constructed. Rhumbler, in 1898, following suggestions and experiments made previously by Hofer and others, demonstrated that a drop of chloroform will attract a shellac thread from the surrounding water and roll it up within its substance, just as an

Amœba rolls up a filament of conferva.* Egg-albumen and gum-arabic in solution evinced the same phenomena, the rapidity of ingestion showing the density of the medium. These phenomena accord with physical laws. Rhumbler found that a splinter of glass inserted in a drop of chloroform suspended in water will leave the chloroform and seek the water, but that, coated with shellac, and then placed in contact with the chloroform drop, the splinter and shellac were quickly drawn into the chloroform. So soon as the shellac was dissolved by this medium, it was expelled, or, to put it more correctly, drawn into the surrounding water, by reason of the greater co-efficient of adhesion between glass and water. Rhumbler drew an analogy between this and the process of feeding in the Rhizopoda. Bodies, he concluded, are ingested into the plasma because of the greater attraction to the fluid protoplasm than to the water; then, through the chemical changes between protoplasm and the digestible parts of the foreign substances, the constituents of the body are changed, and a corresponding change is wrought in the attractive force which keeps them together, that is, in the co-efficient of adhesion, and defecation results.

The Tests.

The tests of the freshwater Rhizopoda are variable in size and form, as well as in the materials of which they are composed. The simple membranous test of the *Cochliopodia*, or that of *Pamphagus hyalinus*, may be regarded as the most rudimentary. It is formed by the secretion of a chitinoid substance, apparently during the life of the individual. From this, as a starting point, we get a great diversity of structural types, from the homogeneous tests of the *Hyalospheniæ* to the tesselated ones of *Nebela* and *Euglypha*, and the coarser *Difflugiæ*, which, not content with a purely

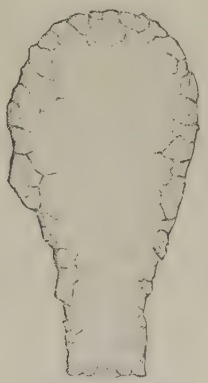
* An *Amœba* 90 μ in length absorbed and coiled up an *Oscillaria* filament measuring 540 μ.

chitinous envelope, fortify and ornament it externally with sand-grains, diatom-tests, and other extraneous substances.

The tests of *Hyalosphenia* are either plane-surfaced, or ornamented with variously-disposed pits or depressions. Those of *Nebela* and *Euglypha* are built up of circular, oval, or hexagonal plates, placed edge to edge, or with the edges overlapping.

The development of the Rhizopodous tests has been closely studied by Gruber, Verworn, and others. In

7



8

Fig. 7.—Test of *Hyalosphenia papilio*. × about 250. Fig. 8.—Test of *Difflugia pyriformis* (a common form) encrusted with sand-grains. × 200.

Euglypha alveolata Gruber concluded that there was a development, within the protoplasmic body, of the necessary materials—chitin, cellulose, or silica—by chemical agency. Diaphanous plates of varied pattern, circular or oval (*Nebela*, etc.), polygonal (some *Euglyphæ*); quadrangular (*Quadrula*); or of no definite geometrical figure, are secreted; and during mitosis (reproductive fission) these so arrange themselves in the newly-formed cell as ultimately to form an external covering, in all respects like that of the parent.* It is

* 'Zeitschr. für Wiss. Zool.,' xxxv (1881), 431. See also Schewiakoff in 'Morphol. Jahrb.,' xiii (1888).

suggested that in the case of *Euglypha* the secretions take place in the ectoplasm.

In some Rhizopoda (*e. g. Sphenoderia*) the test is apparently siliceous. Silica also enters into the composition of the test of *Nebela dentistoma*, as appears by its breaking, under pressure, with an irregular fracture. Simple chitinous membrane, as seen in most *Nebelæ*, etc., does not fracture when subjected to pressure. The homogeneous plane tests of *Arcella*, *Cyphoderia*, and some others, are finely punctated. *Pseudochlamys* secretes a simple protective shield, which, in the earlier stage of the animal's existence, is

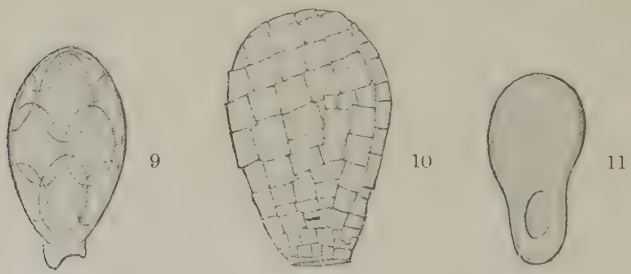


FIG. 9.—Transparent test of *Sphenoderia fissirostris*, composed of large oval plates. × 375. FIG. 10.—Transparent test of *Quadrula symmetrica*, composed of quadrangular plates. × 375. FIG. 11.—Ordinary form of test of *Trinema enchelis*. × 375.

flexible and susceptible of constant change in sympathy with the creature's movements. It is not improbable that some young *Arcellæ*, covered with the same kind of filmy envelope or rudimentary test, are capable of undergoing similar mutations. Forms are sometimes met with which it is difficult to interpret on any other hypothesis.

The *Difflugiæ*, as previously stated, have, in most species, sand-grains and other substances selected from the surrounding medium, superimposed upon a secreted membranous base. Experiments have been made from time to time, by Continental naturalists, upon these structures, with results which are both interesting and suggestive. Verworn (1888) directed his attention

and experiments to a typical *Difflugia*, *D. urceolata*, conjointly with the marine *Polystomella*, in order to ascertain the relation of the plasma-body in each case to the shell-structure and the behaviour of the animals under artificial conditions. The body of an individual *Difflugia*, a portion of whose shell had been removed, was found to be charged with sand-grains, some lying apparently only adherent to, but others completely immersed in, the protoplasm.* Bütschli had some years previously, says this author, intimated the probability that the foreign material employed in the construction of the Difflugian shell was taken up into the protoplasmic body of the animal itself, and subsequently deposited at the surface.† And Gruber, adopting this suggestion, and with reference to the frequently-observed phenomenon that other Rhizopods take up sand-grains, said: "Scarcely any doubt will remain that Bütschli's opinion with regard to the Difflugian shell is correct, and consequently these animals themselves will select and take up into themselves from the water the material—the sand, the Diatomaceæ, or whatever it may be. They thus proceed to divide themselves, and the formation of the new shell takes place in the same way as in *Euglypha*, *Quadrula*, and other Monothalamia."

In order to verify these conclusions, Verworn, in the first place, ascertained the fact of the inception of sand-grains. Finely-powdered dark blue glass was introduced into the water with living *Difflugiæ*, but it was disregarded by the animals until a clumsy entomostracan (*Cypris*) came near a *Difflugia*, and pushed roughly against its pseudopodia. In a few seconds the surface of the widely-extended pseudopodia became wrinkled and knobbed, and some particles of ground glass were observed adhering to them. They were gradually absorbed completely into the interior of the shell along with the pseudopodia. It

* 'Zeitschr. für Wiss. Zool.,' xlvi, p. 455. (Transl. in 'Ann. and Mag. Nat. Hist.,' 1888).

† Bronn's 'Klassen und Ord. des Thierreichs' (1880).

seemed evident that by mechanical irritation a "reflex contraction" of the pseudopodia was produced, and, combined therewith, a secretion of a sticky coat on their surface, which caused the glass granules to adhere to the pseudopodia, and to be drawn in with them.

By a series of experiments repeated upon other species of *Difflugia*, Verworn ascertained the great regularity of this process. When a *Difflugia* had extended its pseudopodia to a great length, and was groping about between the glass plates, it was irritated with a sharp needle; the same effect was then produced with great exactness. The pseudopodia became tubercular, and while previously no glass granules were adherent to them, these now clung firmly, and were slowly drawn into the shell. Specimens, the shells of which were partially removed, showed that the glass grains not only remained adherent to the surface of the protoplasm but were actually drawn into it.

The same writer had subsequent opportunities of observing individual *Difflugiæ* undergoing division, and found that shell-formation in a young *Difflugia* accorded exactly with Gruber's observations in the case of *Euglypha alveolata*. When the protruding mass of protoplasm from the old shell had attained approximately the normal size, he observed that a ball of glass granules had already, in part, entered the newly-formed half, in which the protoplasm with the finely-powdered glass showed a slowly-flowing movement. In a more advanced stage of division the protruded protoplasm had already assumed pretty nearly the form of the Difflugian shell (*D. urceolata*), and the particles of glass had arranged themselves upon its surface. The new half seemed not yet to have a solid shell, but the glass granules were loosely fitted to one another. Upon separation from the parent the newly-formed individual was observed groping about in the water, with pseudopodia extended. The shell exhibited the characteristic form, but the pale bluish glass grains

were united to each other by a narrow, transparent, and originally quite colourless, connective substance, which only some days later began to acquire a dark brownish hue.

Another result of Verworn's experiments was to show that the Difflugian shell, once injured or removed, is incapable of restoration. The whole of the shells of several individuals were removed without injury to the protoplasmic body, and whilst the *Difflugiæ* lived a considerable time—some of them about three weeks—and behaved quite normally, taking up sand-grains, which collected in the interior of the protoplasm, no trace of a regeneration of the shell was observed; the body-surface did not present the least excretion or deposition of solid matter. It was "rather soft, performed amæboid movements, and developed pseudopodia"; in fact it had a strong resemblance to *Pelomyxa*, the likeness being still further increased by the greyish-brown coloration, the incepted glass granules, and the great number of nuclei.

The obvious conclusion is that in all the Monothalamia the test originates at the moment of fission and is completely finished at the separation of the new individual from the parent. The protoplasmic body then ceases to have any secretory relations with the shell: the faculty of shell-formation has ceased.

Upon a review of all the circumstances, and having regard to the fact that whilst injuries to a monothalamous Rhizopod test cannot be repaired, in the polythalamous forms (the Foraminifera) this takes place to the fullest extent, as shown by Verworn's experiments on *Polystomella crispa* and those of Carpenter on *Orbitolites tenuissima* and *O. complanata*. Dreyer, in 'Biologische Centralblatt' (1889) endorsed Verworn's conclusion that the faculty of a soft body of secreting shell-material only continues so long as the normal growth of the shell itself, from which, then, the different behaviour of the mono- and polythalamous Rhizopods may be explained.

Reproduction.

Several modes of reproduction have been observed among the Rhizopoda, but, from the infrequency of their occurrence, some have not been satisfactorily worked out. The modes most frequently noticed are—(1) simple fission or binary self-division; and (2) spore-formation. The latter is little more than the breaking up of the plasma into fragments, and the development of these; each separate portion being the germ, or earliest stage in the existence, of a new individual. This process is usually preceded by the encistment of the adult individual; that is to say, the formation, upon the withdrawal of the plasma into the interior of the test (in the Conchulina) of a spherical or oval cist, which acquires a hard (chitinous or possibly siliceous) coat. The cist remains quiescent for a longer or shorter period, until division of the plasma and nucleus takes place, and the "spores" are liberated. Frequently—but, according to Ray Lankester, not necessarily—two (rarely three or more) individuals come together and fuse before breaking up into spores. This process is known as "conjugation"; and there can be no doubt, says the same authority, that the physiological significance of the process is similar to that of sexual fertilization, namely, that the new spores are not merely fragments of an old individual, but are something totally new, as they consist of the substance of individuals which previously had different life-experiences. Whilst spore-formation is not necessarily preceded by conjugation, conjugation is not necessarily followed by spore-formation. Professor Lankester further remarks: "There is certainly no marked line to be drawn between reproduction by simple fission, and reproduction by spore-formation; both are a more or less complete dividing of the parent protoplasm into separate masses; whether the products of the first fission are allowed to nourish themselves and grow

before further fission is carried out, or not, does not constitute an essential difference." *

Calkins remarks that while the majority of the Protozoa reproduce asexually, as described, reproduction in some is bound up with complete sexual differentiation, and a series of forms may be selected which indicate the probable development of the sexual from the more primitive methods. In numerous cases the sexual phenomena include many of the preliminary maturation stages shown by the Metazoa, in the formation of polar bodies and reduction of the quantity of chromatin, etc.†

Blochmann asserted that "copulation," in which the plasma-bodies of two animals become completely fused together to form a new individual, as well as "conjugation," in which the animals, after long-continued union, separate again from each other, and in which hitherto no demonstrable changes have been observed, actually occur.

In all cases of fission it is important to note the part, in the process, which is taken by the nucleus. Invariably the first signs of division are to be noted in this organ; the separation of the protoplasm, with its contents, into two equal parts, follows, and one half of the nucleus goes to complete the organisation of the new individual. This is, briefly stated, the process observed in the Amœbina.

In the testaceous forms the process is essentially the same. Here division takes place by the extrusion of one half of the plasma-body through the mouth of the shell. Some remarkable phenomena have been described by Blochmann in the case of *Euglypha alveolata*. The protoplasm emerged from the parent-shell, and became covered with shell-lamellæ,‡ forming a new individual of the normal size, which received its moiety of the divided nucleus. But, after this point had been

* Art. "Protozoa" in 'Encycl. Brit.,' 9th ed.

† 'The Protozoa,' p. 55.

‡ 'Morphol. Jahrb.,' xiii (1887), p. 173. See Transl. in 'Ann. and Mag. Nat. Hist.' (6), vol. i (1888).

reached he found that the process was arrested. Separation of the new individual from the parent did not take place; and not infrequently, whilst two shells and two nuclei were produced, only a single animal resulted. The plasma which filled the newly-formed shell was retracted again into the old one, whilst one of the nuclei was thrown off, and perished. The purpose seems to have been accomplished of ridding the parent of its superfluous shell-lamellæ and of a part of its nucleus; but what the precise significance of the act may have been otherwise, is not apparent.

On the other hand it may be assumed that new

Fig. 12.—Stages in the reproduction (division within the test) of *Microgromia socialis* (after Archer). × 500.

individuals are constantly being formed, in many, probably all, of the shelled Rhizopoda, as the result of perfect fission, one half of the divided nucleus always going to the daughter cell.

In some testaceous species complete division takes place within the shell. The daughter individual, furnished with nucleus and contractile vacuole, migrates in the amœboid state, secretes a shell for itself, and may either follow an independent existence or unite with the parent to form part of a colony (*e.g. Microgromia socialis*, *Raphidiophrys viridis*).

A form of division called "budding" has been noted in the *Arcellæ* and some *Difflugiæ*. A plasma "bud"

forms outside the shell-mouth of the parent, and this bud grows, until, having acquired a size approximate to that of the parent, a chitinous test is secreted, and the "bud" falls off and pursues an independent existence. Several "buds" may be formed by a single individual at the same time.

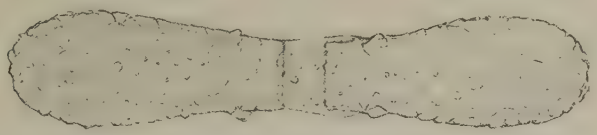


FIG. 13.—Early stage in the conjugation of *Difflugia pyriformis*, var. *lacustris*: two individuals approaching each other, the plasma of the one enveloping the oral aperture of the other, and the granular substance of the two animals commingling. A few minutes sufficed to bring the mouths of the tests close together. × 200.

The cysts, so commonly observed in the testaceous Rhizopoda (*Nebela*, *Difflugia*, *Euglypha*, etc.) protect what are known as "swarm-spores." The parent organism splits up into separate cells, each cell provided with its portion of the nucleus, and also, on liberation, with means of locomotion, which may be

FIG. 14.—Late stage in the conjugation of *Nebela collaris*: two tests closely adhering, one filled with protoplasm, the other nearly empty. In the latter the remaining protoplasm continued to be attached to its test by numerous protoplasmic threads. × 250.

flagella or pseudopodia. These either undergo subsequent fission or develop at once into the typical form.

Encistment is probably preceded by the conjugation ("copulation," Blochmann) of two individuals. It has been observed in many testaceous forms. Individuals in pairs, having the mouths of their tests closely

adhering, are of frequent occurrence. Where the tests are sufficiently transparent, a streaming of the protoplasm may be observed from one shell into the other (*e. g. Euglypha*, *Cyphoderia*), slow but continuous, until one shell is entirely emptied. The pair will remain attached for a considerable time, and it is presumed that after separation the encistment of the united protoplasm, in the test which contains it, is completed, there to undergo subsequent division and to produce "swarm-spores."

Vampyrella is said to reproduce while encisted, by dividing into a number of parts, each of which emerges provided with pseudopodia like those of the parent. It has been observed, however, in the case of *V. lateritia*, that young amœboid forms escape from the parent and pursue a separate existence, first as amœbulæ. These are liable to be mistaken, without careful scrutiny, for actual *Amœbæ*. At the time of, and immediately subsequent to, extrusion, they have sharply-pointed pseudopodia; but after a while the pseudopodia become blunt, completing the resemblance to some of the smaller forms of *Amœba proteus* and even of *Dactylosphærium radiosum*. Their after-development has not been traced with certainty, but it is assumed, no doubt with good reason, that in a short time these off-shoots, or plasma-spores, of the *Vampyrella* develop into mature individuals. They are destitute of any flagellum.

In *Pelomyxa*, again, spore-formation, divergent in form, but probably not in substance, from the general type, has been noted. This organism is multi-nucleated, the nuclei being small and distributed throughout the plasma-body. An individual was observed by Greeff to liberate a number of amœbulæ, which he thought might be its spore-like young. The animal at first seemed as if in the act of breaking up. Around the whole outer margin of the *Pelomyxa* there came forth an incalculable number of minute amœbulæ, surrounding the parent body in a thick annularly-arranged crowd. These had all the same habits, movements, and size;

and showed also a nucleus and nucleolus, and a contractile vesicle, the latter mostly posterior.* Gradually these bodies settled down. In place of the vigorous amœboid contractions of the whole body, merely hyaline lobes or finger-like processes were extended; as they contracted one by one into a globular subpyriform figure, a resting-state set in; then a long vibrating filament was projected from the body, and the metamorphosis of the amœbula into a flagellate spore was complete. The author did not follow their development further. They were not, he considered, in any sense parasitic, but had their origin in the peculiar "shining bodies" (glanzkörper) which occur in large numbers, along with the small nuclei, in the plasma-body of *Pelomyxa*. These shining bodies are of roundish, ovoid, or irregular figure, and glossy appearance. In an individual not very highly charged with extraneous matter they may readily be detected.

From these remarks it will be seen how diverse are the forms under which reproduction takes place in the simple-celled Rhizopoda. The Heliozoa present no essential difference; but these will be more conveniently dealt with under their own proper head.

It may not be out of place to allude here to the theory of Weismann and others of the "deathlessness" of the Protozoan cell, thus expounded by Prof. Ray Lankester: † "It results from the constitution of the Protozoan body as a single cell, and its multiplication by fission, that death has no place as a natural recurrent phenomenon among these organisms. Among the Enterozoa certain cells are separated from the rest of the constituent units of the body as egg-cells and sperm-cells; these conjugate and continue to live, whilst the remaining cells, the mere carriers as it were of the immortal reproductive cells, die and disintegrate. There being no carrying cells which surround, feed, and nurse the reproductive cells of Protozoa, but the

* 'Arch. f. Mikr. Anat.,' x, p. 51.

† "Protozoa," in 'Encyclopædia Britannica,' 9th ed. XIX (1885).

reproductive cell being itself and alone the individual Protozoan, there is nothing to die, nothing to be cast off by the reproductive cell when entering on a new career of fission. . . . Experiment and observation in this matter are extremely difficult, but we have no reason to suppose that there is any inherent limit to the process of nutrition, growth, and fission, by which continuously the Protozoa are propagated. The act of conjugation from time to time confers upon the protoplasm of a given line of descent new properties, and apparently new vigour. Where it is not followed by a breaking-up of the conjugated cells into space, but by separation and renewed binary fission (Ciliata), the result is described simply as 'rejuvenescence.'"

This theory, which Ehrenberg first suggested, seems to us to be based upon insufficient data. The available evidence is directly opposed to such a supposition as the immortality of living matter in any form. The protoplasmic cell does "die and disintegrate." Opportunities for observation, it is true, are rare. One, within our own experience, may be worth placing on record here. During an examination of pond-water an *Amœba* entered the field of view, in the condition represented in figure 15 *a*. The main body was advancing in *Amœba* fashion by lobular expansions anteriorly, but dragging behind a trail of its own protoplasmic substance. This was clearly an abnormal condition, and in endeavouring to account for it one was led to suppose that the organism had somehow met with an accident by which its body had been so torn as to form a kind of tail with a terminal bulb, about midway between which and the main body there was a slight thickening.

Curiosity led us to keep the animal under observation for about an hour and a half. During that period the terminal bulb became separated and assumed a spherical shape (*c*); afterwards the middle portion separated; and at last the main body ceased to show any indication of life, and rounded out into a spherical

ball. There were, therefore, three portions of protoplasm of different sizes representing the original organism. Whilst under the microscope they went through the successive phases represented, until, finally, the larger sphere burst, as the smaller one had done before it, and its granular contents were dispersed. There was no indication of life in any of the dispersed granules, and all that remained of each spherule was a ring of hardened ectoplasm. That this was a case of spore-dispersion is beyond the region of possibility.

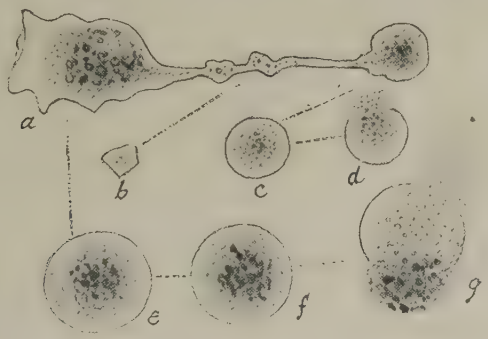


Fig. 15.—Stages in the dissolution of *Amæba proteus*. *a*, Condition of the living individual as first seen; *b*, *c*, fragments of protoplasm which became detached from the main body; *d*, the larger of the two fragments burst and the contents dispersing; *e*, *f*, *g*, stages in the dissolution of the main body; at *g* the body has finally dissolved, leaving only a ring of hardened ectoplasm. × 150.

The death of a Protozoan being so speedily followed by disintegration, it is not surprising that but few opportunities should occur of witnessing it.

Distribution, Habitats, etc.

The Rhizopoda are cosmopolitan. There is no quarter of the globe destitute of them, and whilst climate may favour an exuberance of certain forms, it is a curious fact that many which are familiar to us, in these islands, are quite as plentiful, varying hardly at all in structure, in such widely separated regions as America and

Australia. *Clathrulina elegans* is much more abundant in the waters of Pennsylvania than with us, and *Lecquereusia spiralis* is as common in swampy places in the Far West, and in New South Wales, as in the Sphagnum-bogs of Britain. The Difflugias, Hyalospheniias, Nebelas, and Heleoperas, the crystalline *Quadrula vulgaris*, the Euglyphas, and many others, occur in equal abundance on both sides of the Atlantic.

The Rhizopoda inhabit ponds and lakes, marshes and swamps; wherever, in fact, enough moisture exists to support a tuft of moss. They are plentiful in still pools, on submerged vegetation, and in the surface-ooze of ponds and ditches. At pond-sides, among the stems of sub-aquatic *Hypna*, about the roots of *Bartramia fontana* and *Aulacomnium palustre*, they may at all times be found. Moist dripping rocks in sub-Alpine districts and near the coast, in tufts of *Barbula* and similar mosses; and the walls of aqueducts, where frequently there is a percolation of water through crevices of the masonry, sometimes yield the very rare species. They nestle in the foliage of mosses and liverworts, and among the masses of Confervæ and other lowly vegetation which affect such situations. The Rhizopoda in these localities are not infrequently associated with such diatoms as *Campylodiscus clipeus* and *Asterionella formosa*, besides numerous Desmidian forms. *Difflugia constricta*, *D. globulosa*, and often *D. arcula*, with some forms of *Arcella*, find sufficient moisture to sustain life in tufts of moss growing on the trunks of trees and about their roots in shady woods.

Various *Amœbæ*, *Pelomyxa*, and most of the *Arcellæ*, as well as *Difflugiæ*, are commonly found in ponds and ditches, and creeping about the foliage of aquatic vegetation, where they feed upon desmids, diatoms, and Algæ of various kinds. The flocculent matter which invests the finely-divided leaves of *Ceratophyllum*, *Utricularia*, and the aquatic *Ranunculi*, harbours a great variety of Rhizopod life; and some special and rare kinds, such as *Amœba pilosa*, should be sought for in

such situations. The under-sides of the leaves of water-lilies, the common *Potamogeton*, and other submerged plants, are likewise prolific of species. But for the finer forms of *Hyalosphenia*, the Nebelas, Heleoperas, etc., search must be made in Sphagnum-bogs and moorland pools. It is in such places that the rare *Raphidiophrys elegans*, *Amphitrema* (*Ditrema*) *flavum*, and *A. Wrightii* were discovered by Mr. Archer, in Ireland, and there also the singular *Chlamydomyxa* and the rarer Heliozoa may be looked for with success.

In matters of habitat the Rhizopoda, like other creatures, have their preferences. It would be in vain, for example, to look for the beautiful Hyalosphenias, the Nebelas, or the rarer Reticularian species in the deep waters of a pool, or for *Pelomyxa* amongst *Sphagnum*. Professor Penard has shown, by his investigations at Geneva, that the deep waters of a lake may contain new and unsuspected forms of life. The *Amœbæ*, *Difflugiæ*, and *Arcellæ* seem indifferent to situation. Some of the rarer kinds may be gathered on dripping sandstone rocks among low forms of vegetation.

Bogs, again, harbour the rarer species of the filose protoplasts. They are also the habitats of the naked Reticularians, *Biomyxa*, *Gymnophrys*, and *Penardia*, and also of *Chlamydomyxa*, which in its resting-state is parasitic on *Sphagnum*. The moss *Dicranella cerviculata*, which covers with a velvety-green mantle the sides of deep drains on peat-bogs, gives shelter to a great variety of forms, notably the delicate little *Pamphagus hyalinus*, as well as some of the smaller *Euglyphæ*, *Cyphoderia ampulla*, *Trinema acinus*, *Assulina seminulum*, etc. *Nebela bursella* is met with in association with these, but in an ill-developed state usually arising from insufficient moisture in summer. *Microgromia* occurs in colonies, mostly in shallow bog-pools, along with *Pompholyxophrys*, *Acanthocistis*, and *Vampyrella lateritia*, but not invariably so. We have met with it in sluggish streams, in masses of filamentous algæ, and in ponds among the foliage of aquatic *Hypna* ;

but in the latter situation not in large colonies—half-a-dozen individuals together being the maximum number. Usually they occur as single individuals or in pairs, or in small colonies of four or six.

Collecting.

For the reception of pond-gatherings, squeezings of *Sphagnum* and other aquatic mosses, and the often unattractive and slimy-looking algæ found growing on dripping rocks, the collector of Rhizopoda should be furnished with a number of wide-mouthed bottles or test-tubes, the latter preferably, as the thinness and clearness of the glass admits of inspection in the field with a high-power lens.

A vasculum is the most convenient receptacle for tufts of wet moss, *Sphagnum*, etc., from bogs and pond-sides. It is desirable to make a note of the localities from which these are taken, in order that the habitat of any rare species which may turn up during microscopical examination may be noted. Provided it be kept moist, and in a growing state, the *Sphagnum*, etc., with the Rhizopodous life which it harbours, may be preserved for weeks or months, affording material for constant study. It is desirable to bear this in mind when a summer excursion to Wales or Scotland is contemplated. A gathering of *Sphagnum* can be kept perfectly fresh through the winter in a garden-frame.

Water, in small bottles, is apt to get foul unless some growing vegetation be kept in it. At the same time, if from a locality rich in Rhizopoda, it would be unwise to throw it away too soon. A stem of *Anacharis* or *Callitriche* introduced into a two- or three-ounce bottle of water, at the time of gathering, will keep it sweet and healthy for many weeks. In a short time the side of the tube nearest to the light will become crowded with Rhizopod life, especially with such testaceous forms as *Arcellæ* and *Centropyxis*, and with *Actinospherium* or other Heliozoa. A peculiarity of the

rare and curious *Ciliophrys infusionum* is that, necessarily or otherwise, it most frequently occurs in water which has been kept two or three weeks in association with fragments of pond-vegetation. The occurrence of particular species, year by year, in the same ponds, is not, however, to be relied upon.

An aquarium, in which some fine-leaved plants, *e. g. Hottonia palustris*, *Utricularia vulgaris*, and *Ranunculus aquatilis*, are kept growing without being often disturbed, is a valuable adjunct to the study of the Rhizopoda.

Preservation.

By the employment of dilute nitric acid or sulphuric acid it is possible to isolate the Rhizopod nucleus; when carmine staining renders a study of that organ quite practicable. The process, however, is a delicate one. Dr. Eugene Penard has, by the exercise of much care and patience, preserved in suitable media numerous examples for reference. Where they can be made, permanent preparations are no doubt desirable and useful, inasmuch as they facilitate a study of the nuclear structure under high powers of the microscope, but the ordinary student will probably be content to make careful drawings from living examples, in different aspects and under varying conditions of their existence. These, together with descriptive notes, should in all cases be preserved.

The transparent tests of some of the Conchulina, when freed from extraneous matter, may be preserved in glycerine jelly, and the gritty tests of various species of *Difflugia* can be mounted as opaque objects in the same manner as Foraminifera. Beautiful examples, obtained by repeated washings of the mud from a pond at Chipperfield, Herts, have been obtained by Mr. Arthur Earland, showing that this method of treating the *Difflugiæ* is feasible and yields good results.

CLASSIFICATION.

Dujardin* made one of the earliest attempts at a classification of the Protozoa, and in his second order of the Infusoria, in which he placed his "*Animaux pourvus d'expansions variable*," he approached very nearly to the classification of the present day. The three families into which he divided this order—Amibiens, Rhizopodes, and Actinophryens—correspond closely with (1) the Amœbina, (2) the Conchulina and Foraminifera, and (3) the Heliozoa. Moreover he grouped his three families into two sections, placing the Amibiens and Rhizopodes in one, and the Actinophryens in the other, as we now differentiate the Rhizopoda from the Heliozoa. Later, von Siebold† divided the Protozoa into two classes, the Rhizopoda and the Infusoria, the former including the above three families of Dujardin. This obviously natural primary division served for a time; but advancing knowledge rendered further systematization indispensable.

Four classes or main groups of Protozoa are now generally recognized, namely, the Sarcodina (with the Heliozoa), at the bottom of the scale; the Mastigophora or flagellates; the Sporozoa; and the ciliated Infusoria. The inter-relations of the Sarcodina, the only class with which we are now concerned, remain more or less uncertain. Obscurity surrounds the life-history of many forms, rendering a perfect division into genera and species for the present impracticable. Haeckel separated the (supposed) non-nucleated forms from the nucleated, or those in which the existence of a nucleus had been demonstrated, in order to establish

* 'Hist. Nat. des Zoophytes. Infusoires,' 1841, p. 126.
† 'Anatomie der Wirbellosen Thiere,' 1848, p. 3.

a class, the Monera or Homogenea, regarded by him as occupying a lower plane in the evolution or differentiation of structure. Others, notably Bütschli, considered a merely negative distinction valueless, and subsequent investigation has confirmed their judgment. The presence of nuclei or nuclear substance, in some form, has been demonstrated in many species where formerly it was not suspected. Assuming Bütschli's dictum to be well grounded, that "the nucleus needs the plasm and the plasm the nucleus," in the development of a perfect organism—that the activities of both are reciprocal, and one without the other cannot live, a conclusion strongly deducible from all that has been ascertained regarding their vital functions—Haeckel's separation of the apparently non-nucleated forms from the general group seems unwarranted, and his term "Monera," and also "Homogenea," should disappear.

Professor Lankester describes the substitution, in his genus *Archerina*, of a chlorophyl-coloured capsule for the nucleus proper,—it is representative, in fact, of the nucleus,—and whilst refraining from the assertion that no existing Protozoa are devoid of nucleus, corresponding in this character with the non-nucleated Protophyta (*e. g.* Bacteria), he found the inclusion, in his proposed system of classification, of the Homogenea, impracticable, and chose to defer taking that step until it had been conclusively shown that forms now regarded by some as homogeneous (*Biomyxa*, *Gymnophrys*, etc.) are really so. The general relations of these apparently non-nucleated forms with the nucleated most nearly allied to them cannot be ignored in any systematic arrangement. And, it may be added, in any case the form of the nucleus, when present, is of little specific value.

The arrangement here adopted is, in its main features, on the lines now most generally accepted by Continental authors, whose long-sustained and fruitful investigations entitle them to respect.

CLASS SARCODINA.

Protozoa naked or testaceous, possessing, in maturity, digitate, lobose, finely reticulate, or radiate pseudopodia, the latter with or without axial filaments. Reproduction by spore-formation or simple division.

SUB-CLASS RHIZOPODA.

Naked or testaceous Sarcodina, with pseudopodia of the lobose, digitate, acicular, or reticulate types. Adult forms amœboid; young (spores) amœboid or flagellate, produced by cell-division during life or following encistment. In some forms (*e. g. Vampyrella voraæ*) individuals fuse to form plasmodia.

Order I. AMŒBINA.

Plasma-body naked.

Family 1. Lobosa.

Naked Rhizopods with lobose, or more or less digitate, elongate, sharply pointed or blunt pseudopodia, or with wave-like or hernia-like expansions of the ectoplasm.

Genera: (1) *Amœba*, (2) *Dactylosphærium*, (3) *Mastigamœba*, (4) *Pelomyxa*, (5) *Lithamœba*, (6) *Ouramœba*.

Family 2. Reticulosa.

Naked Rhizopods with filamentous anastomosing pseudopodia.

Genera: (7) *Gymnophrys*, (8) *Biomyxa*, (9) *Penardia*, (10) *Chlamydomyxa*.

Family 3. Vampyrellida.

Naked Rhizopods with amœboid movements and variable pseudopodia, sometimes radiate, simulating

those of the Heliozoa; and with one or more usually-obscure nuclei.

Genera: (11) *Vampyrella*, (12) *Hyalodiscus*, (13) *Nuclearia*, (14) *Archerina*.

Order II. CONCHULINA.

(*Testacea*,* Max Schultze.)

Rhizopods furnished with a test, of variable shape and construction.

Family 1. Arcellida.

Test chitinous, with or without extraneous matter adhering; monothalamous; nucleus single or multiple; contractile vacuoles one or several.

Genera: (15) *Arcella*, (16) *Pseudochlamys*, (17) *Centropyxis*, (18) *Difflugia*, (19) *Pontigulasia*, (20) *Difflugiella*, (21) *Lecquerensia*, (22) *Nebela*, (23) *Hyalosphenia*, (24) *Heleopera*, (25) *Quadrula*, (26) *Cochliopodium*, (27) *Leptochlamys*, (28) *Phryganella*.

Family 2. Euglyphina.

Test homogeneous, or composed of chitinous or siliceous plates often of geometrical pattern; spinous or naked. Pseudopodia filose, sharply pointed, simple or branched, but not anastomosing, of variable length, emitted from the mouth of the test.

Genera: (29) *Euglypha*, (30) *Placocista*, (31) *Assulina*, (32) *Cyphoderia*, (33) *Trinema*, (34) *Corythion*, (35) *Sphenoderia*, (36) *Campascus*, (37) *Pamphagus*.

Family 3. Gromiina.

Test membranous, pellucid, rarely covered with extraneous matter; with a single aperture. Pseudopodia long, branching, straight, or irregularly dendroid, frequently anastomosing.

* Pre-occupied in Mollusca.

Genera: (38) *Pseudodifflugia*, (39) *Diaphoropodon*, (40) *Microgromia*, (41) *Gromia*, (42) *Lieberkuhnia*.

Family 4. Amphistomina.

Filose Rhizopods with membranous chitinoid tests which have pseudopodial openings at opposite poles.

Genera: (43) *Diplophrys*, (44) *Amphitrema*.

CLASS SARCODINA.

SUB-CLASS RHIZOPODA.

Order I. AMŒBINA.

Family 1. Lobosa.

Naked Rhizopods, with lobose, or more or less digitate, elongate, sharply pointed or blunt pseudopodia, or, in place of these, and serving the purpose of locomotion, wave-like or hernia-like expansions of the ectoplasm.

Synopsis of the Genera.

Plasma-body naked (in one species clothed with fine spicules); in size very variable; pseudopodia digitate and extensile, or taking the form of lobate, wave-like, or hernia-like expansions; nuclei one or more (usually single); contractile vacuole mostly single. 1. *Amœba.*

Pseudopodia radiate, rigid when at rest, often for considerable periods, widely extensile, blunt at the apex and linear, or tapering to a fine point; straight or curved, sometimes bent at an angle, or spirally twisted. Uninuclear. Contractile vacuole usually conspicuous. 2. *Dactylosphærium.*

Flagellate, the single flagellum extended in front during progressive movement of the individual; the plasma-body and pseudopodia, in adult examples, habitually covered with fine, hardly perceptible bacilliform spiculæ, or naked. Uninuclear. 3. *Mastigamœba.*

Plasma-body naked, multinucleate; contractile vacuoles inconspicuous; pseudopodia lobular or wave-like,

occasionally digitate, and, in the resting phase of the organism, persistent. 4. *Pelomyxa*.

Body discoid, pseudopodia lobose (hernia-like); endoplasm containing numerous minute reniform concretions; nucleus large, punctate. 5. *Lithamœba*.

Amœboid; the plasma-body furnished at the posterior extremity with numerous straight, usually articulate, protoplasmic filaments. 6. *Ouramœba*.

Genus 1. **AMŒBA** Ehrenberg, 1832.

Volvox (pars) Linnæus Syst. Nat. ed. 10, I (1758), p. 820.
Chaos (pars) Linnæus Syst. Nat. ed. 12, I, pt. 2 (1767), p. 1326.
Vibrio (pars) O. F. Müller Verm. Terr. et Fluv. I (1773), p. 45.
Proteus (pars) O. F. Müller Animalc. Infus. (1786), p. 9. Non *Proteus* Baker Empl. Micr. (1753), p. 260.
Amiba (pars) Bory de St. Vincent in Dict. class. Hist. Nat. I (1822), p. 261.
Amœba (pars) Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1831 (1832), p. 79; and Infus. (1838), p. 126.

Plasma-body normally a soft irregularly-spherical or ovate particle of animated protoplasm, having one or more nuclei and pulsating vacuoles, but otherwise structureless, and without any apparent investing membrane; possessing inherent extensile and contractile power. Locomotion effected by lobular expansions or extensions of the hyaline ectoplasm, originating on any part of the body-surface, and forming in some species broad lobes, in others digitate processes, short or elongated (sometimes branching), active or rigid, blunt or sharply-pointed. Endoplasm granular, semitransparent, in some rare examples nearly opaque. In the quiescent (encisted) state, according to Leidy, the body is purged of food and other ingested matter, and becomes uniformly globular or elliptic, and invested with a structureless membrane.

Individuals differ greatly in size as well as in vital activity, but all have the same plastic body, more or

less transparent, and susceptible of constant change, the result of pseudopodal action. The pseudopodia are never elongated and rigid, as in the resting-phase of *Dactylosphærium radiosum*. From the genus *Pelomyxa*, with which they are apt to be confounded, the *Amœbæ* differ in possessing usually but a single nucleus, all the known British *Pelomyxæ* being multinucleated, much larger, and more slug-like in movement than the largest *Amœbæ*, and also more opaque from the inception of large quantities of inorganic matter.

1. **Amœba proteus** (Pallas) Leidy.*

(Plate I, figs. 1–6; Pl. III, fig. 2; and figs. 2, 5, 6, and 15, in text.)

Der kleine Proteus Rösel Insecten-Belüst. (1755), p. 621, t. ci.
Volvox chaos Linnæus Syst. Nat. ed. 10, I (1758), p. 821.
Volvox proteus Pallas Elench. Zooph. (1766), p. 417.
Chaos protheus Linnæus Syst. Nat. ed. 12, I, pt. 2 (1767), p. 1326.
Vibrio proteus O. F. Müller Verm. Terr. et Fluv. I (1773), p. 45; Gmelin Linnæi Syst. Nat. ed. 13 (1788), p. 3899.
Proteus diffluens O. F. Müller Animalc. Infus. (1786), p. 9, t. ii, ff. 1–12; Adams Ess. Micr. (1787), p. 477, t. xxv, ff. 2, 3; Bory de St. Vincent Vers, I (1791), p. 2, t. i, f. 1, in Tabl. Encycl. Méth; Lamarck Syst. Anim. s. Vert. (1801), p. 596, and Hist. Nat. Anim. s. Vert. I (1815), p. 416; Schrank Fauna Boica, III (1803), 2, p. 24; Blainville in Dict. Sci. Nat. (1826), p. 398; Hoeven Handb. Dierk. I (1828), p. 50; Stark Elem. Nat. Hist. II (1828), p. 450; Pritchard Animalc. (1834), p. 36, t. i, ff. 8–12.
Proteus crystallinus Schrank Fauna Boica, III (1803), 2, p. 24.
Amiba divergens Bory de St. Vincent in Dict. class. Hist. Nat. I (1822), p. 261.
Amiba Rœselii Bory de St. Vincent Zooph. (1824), p. 46, in Encycl. Méth.; Dujardin Infus. (1841), p. 232.

* The synonymy is not exhaustive, but it is hoped that it may be found useful as indicating most of our sources of information on the various species and their distribution. In a few cases the first and last or even only one edition of a work is quoted, and some inferior illustrations in recent works are not referred to.

Amiba Mulleri Bory de St. Vincent Zooph. (1824), p. 46, in Encycl. Méth.

Amœba diffluens Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1830 (1832), pp. 39, 61, 78, t. i, f. v; *op. cit.* 1831 (1832), p. 79; and Infus. (1838), p. 127, t. viii, f. xii; Blainville Man. d'Actinol. (1834), p. 623; Rymer Jones Anim. Kingd. (1841), p. 54, f. 16, and in Todd's Cyclop. Anat. IV, 1 (1847), p. 10, f. 6, nos. 7–13; Schmarda Kleine Beitr. Naturges. Infus. (1846), p. 30; Brightwell Fauna Infus. E. Norfolk (1848), p. 29, t. xi, f. 3; Siebold Anat. wirb. Thiere (1848), p. 20, and (Engl. transl.) Anat. Invert. (1854), p. 30; Pritchard Hist. Infus. (1842), p. 166; new ed. (1852), p. 202; and ed. 4 (1861), p. 549; Perty Kenntn. kleinst. Lebensf. (1852), p. 188; Cole in Proc. Essex Inst. I (1853), p. 45; Owen Invert. Anim. ed. 2 (1855), p. 25; Hoeven Handb. Zool. (Engl. transl.) I (1856), p. 46, t. i, f. 2; and Atlas Leerb. Dierk. (1865), p. 7, t. i, f. 1; Pick in Verh. Vereins Wien, VII (1857), p. 36; Hogg Microsc. ed. 3 (1858), p. 266, f. 163, to ed. 1882, p. 373, f. 206; Gosse Ev. Microsc. (1859), p. 459, f.; Engelmann in Arch. Néerl. IV (1869), p. 434; Maggi in Rend. R. Ist. Lomb. (2) IX (1876), p. 440, etc., and *op. cit.* (2) XXI (1888), p. 308; Géza in Herausg. Nat.-Mus. Budapest, I (1877), p. 166; Cattaneo in Boll. Scient. I, an. 1 (1879), pp. 7, 57; an. 3 (1882), p. 116; and *op. cit.* III, an. 10 (1888), pp. 91, 96; Parona in Boll. Scient. I, an. 2 (1880), p. 24, and an. 4 (1882), pp. 51, 56; Lockwood in Amer. M. Micr. Journ. VI (1885) p. 46; Sacchi in Boll. Scient. III, an. 10 (1886), p. 41; Cuneo in Boll. Scient. III, an. 12 (1888), p. 117; Frenzel Mikr. Fauna Argent. I, Prot. 1 (1892), p. 122, in Bibl. Zool. IV; Longi in Atti Soc. Ligust. VI (1895), p. 67.

Amœba princeps Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1831 (1832), pp. 28, 79; Infus. (1838), p. 126, t. viii, f. x; and in Ber. K. Akad. Wiss. Berlin, 1853, p. 255; Pritchard Hist. Infus. (1842), p. 165, t. ii, ff. 85–87; new ed. (1852), p. 201, t. ii, ff. 85–87; and ed. 4 (1861), p. 549, t. xxi, f. 4; Schmarda Kleine Beitr. Naturges. Infus. (1846), p. 30; Bailey in Smithson. Contrib. II (1851), Art. 8, *passim*; Perty Kenntn. kleinst. Lebensf. (1852), p. 188; Auerbach in Zeits. f. wiss. Zool. VII (1856), p. 407, t. xxii, ff. 1–10; Carpenter Microsc. (1856), p. 465, f. 191; to ed. 5 (1875), p. 473, f. 252; and Foram. (1862, *Ray Soc.*), p. 24, t. i, f. 16; t. iv, f. 6; Pick in Verh. Vereins Wien, VII (1857), p. 36;

Rymer Jones Anim. Kingd. ed. 3 (1861) and ed. 4 (1871), p. 19, f. 8; Carter in Ann. Nat. Hist. (3) XII (1863), p. 30, t. iii, ff. 1–5; and *op. cit.* (3) XIII (1864), pp. 19, 25; Carus Handb. Zool. II, Prot. (1863), p. 591; Greeff in Sitz.-ber. Nat. Ver. Rheinl. XXIII (1866), p. 11; Parfitt in Trans. Devon. Assoc. III (1869), p. 65: Somerville Molec. and Micr. Sci. II (1869), p. 14, f. 86; Tatem in M. Micr. Journ. I (1869), p. 352, t. xvii, f. A; Leidy in Proc. Acad. Nat. Sci. Phil. 1874, pp. 14, 143; Maggi in Rend. R. Ist. Lomb. (2) IX (1876), p. 443; Géza in Herausg. Nat.-Mus. Budapest, I (1877), p. 166; Cattaneo in Boll. Scient. I, an. 1 (1879), p. 7, and *op. cit.* III, an. 10 (1888), p. 96; Du Plessis in Bull. Soc. Vaud. (2) XVI (1879), pp. 166, 325; Bütschli in Bronn's Thier-Reichs, I, 1 (1880), t. ii, f. 1; McAlpine Biol. Atlas (1880), p. 17, t. ix, ff. 1, 2; Parona in Boll. Scient. I, an. 2 (1880), pp. 24, 46, 48, and an. 4 (1882), pp. 51, 56; Lanessan Traité Zool. I (1882), p. 39, etc., f. 30; Brass Biol. Studien, I, 1 (1883), t. ii (*pars*), t. iii; Ray Lankester in Encycl. Brit. ed. 9, XIX (1885), p. 842, f. iv, 4; Nicholson Man. Zool. ed. 7 (1887), p. 74, f. 16B; Binet Vie psych. in Études Psych. expér. (1888, 1891), p. 94, and (Engl. transl.) Psychic Life (1889), p. 5; Meissner in Zeits. f. wiss. Zool. XLVI (1888), p. 498; Sacchi in Boll. Scient. III, an. 11 (1889), p. 67; Shipley Zool. Invert. (1893), p. 10; King in J. Quek. Micr. Club (2) V (1894), p. 415, t. xix, ff. 7–10; t. xx, ff. 3–5; Delage & Hérouard Zool. concr. I (1896), p. 93, f. 95; Monti in Rend. R. Ist. Lomb. (2) XXXII (1899), p. 161.

Amiba princeps Dujardin Infus. (1841), p. 232, t. i, f. 11; Crevier in Nat. Canad. VII (1875), p. 274, f. 24.

Amiba diffluens Dujardin in Ann. Sci. Nat. (2) IV (1835), p. 353, t. x, ff. d, e, and Infus. (1841), p. 233, t. iii, f. 1; Schoch Mikr. Thiere, I (1868), p. 9, t. i, f. 16; Crivelli & Maggi in Rend. R. Ist. Lomb. (2) III (1870), p. 369; Crevier in Nat. Canad. VII (1875), p. 275, f. 25.

Amœba Rœselii Pritchard Hist. Infus., new ed. (1852), p. 202, and ed. 4 (1861), p. 549.

Amœba oblonga Schmarda in Denks. K. Akad. Wiss. Berlin, VII (1854), 2, pp. 6, 25, t. ii, f. 1.

Amœba Rœselii (?) Carter in Ann. Nat. Hist. (2) XVIII (1856), p. 243, t. v, ff. 4, 24.

Amiba Kœselii (male pro *Rœselii*) Crevier in Nat. Canad. VII (1875), p. 275.

Amœba diffluens Maggi in Rend. R. Ist. Lomb. (2) IX

(1876), p. 541 ; in Atti Soc. Ital. XIX (1876), p. 399, etc. ; and in Boll. Scient. I, an. 2 (1880), p. 37.

Amœba princeps Maggi in Rend. R. Ist. Lomb. (2) IX (1876), p. 541.

Amœba proteus Leidy in Proc. Acad. Nat. Sci. Phil. 1876, p. 99 ; in Amer. Nat. XII (1877), p. 235 ; and Freshw. Rhiz. N. Amer. (1879), p. 30, t. 1, ff. 1–8 ; t. ii, ff. 1–13 ; t. iv, ff. 22–25 ; t. vii, ff. 13–19 ; t. viii, ff. 17–30 ; Fullagar in Sci. Goss. 1880, p. 204, ff. 121–124 ; Carpenter Microsc. ed. 6 (1881), p. 486, f. 289, to ed. 8 (1901), p. 742, f. 577 ; Hitchcock Synops. Freshw. Rhiz. (1881), p. 4 ; Brooks Invert. Zool. (1882), p. 1, f. 1 ; Nicholson Classif. Anim. Kingd. (1882), p. 5, f. 3a, and Man. Zool. ed. 7 (1887), p. 75, f. 17a ; Vejdovsky Thier. Org. Brunn. Prag (1882), p. 34, t. i, ff. 3–5 ; Phillips in Trans. Herts N. H. Soc. II (1883), p. 121 ; Gruber in Zeits. f. wiss. Zool. XXXVIII (1883), p. 372 ; *op. cit.* XL (1884), pp. 127, 130, t. viii, f. 12 ; and *op. cit.* XLI (1885), p. 216, t. xv, ff. 43–45 ; Blochmann Mikr. Thierw. Süsswass. (1886), p. 10, t. i, f. 6 ; ed. 2 (1895), p. 13, t. i, f. 3 ; and in Biol. Centralbl. XIV (1894), pp. 87, 89 ; Bolton in Midl. Nat. IX (1886), p. 174 ; Greenwood in Journ. Physiol. VII (1886), p. 258 ; *op. cit.* VIII (1887), p. 263, t. viii, ff. 1–7 ; and *op. cit.* XI (1890), p. 575 ; Whitelegge in Proc. Linn. Soc. N. S. Wales (2) I (1886), p. 499 ; Harvey in Amer. Nat. XXII (1888), p. 72 : Rolleston Forms Anim. Life, ed. 2 (1888), pp. 256, 899, f. 13c ; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 123 ; in Arch. Sci. Phys. XXVI (1891), p. 137 ; in Rev. Suisse Zool. VII (1899), p. 14, t. 1, ff. 1–6 ; *op. cit.* IX (1901), p. 237 ; and Faune Rhiz. Léman (1902), p. 57, ff. ; Helm in Journ. New York Micr. Soc. VII (1891), p. 58 ; Hertwig Lehrb. Zool. 1 (1891), p. 149, f. 111, and (Engl. transl. ed. 1900) Man. Zool. (1903), p. 187, f. 116 ; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 94 ; Voeltzkow in Zool. Anzeig. XIV (1891), p. 228 ; Bütschli Mikr. Schäume (1892), pp. 72, 202, and (Engl. transl.) Micros. Foams (1894), p. 107 ; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 48 ; Frenzel Mikr. Fauna Argent. I, Prot. 1 (1892), p. 22, t. iv, f. 8, in Bibl. Zool. IV ; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 56 ; Jelliffe in Amer. M. Micr. Journ. XIV (1893), p. 289 ; Schiewiakoff in Mém. Acad. Impér. Pétersb. (7) XLI, no. 8 (1893), p. 5 ; Le Dantec in Compt. Rend. CIX (1894), p. 1279, and *op. cit.* CXX (1895), p. 210 ; Levan-

DER in Acta Soc. Fauna Fenn. XII (1894), no. 2, p. 8; RHUMBLER in Arch. f. Entwick. VII (1898), p. 169, f. 29; STENROOS in Acta Soc. Fauna Fenn. XVII (1898), no. 1, pp. 32, 85; SCHEEL in Sitz.-ber. Ges. München, XV (1899), p. 90; in Festsch. C. von Kupffer (1899), p. 569, t. li; and (abstr.) in Amer. Nat. XXXIV (1900), pp. 332, 441; ZACHARIAS in Biol. Centralbl. IX (1899), p. 58; CALKINS Protozoa (1901), *passim*, ff. 10A, 17A, 49, and in Amer. Nat. XXXV (1901), p. 645, etc.; ISSEL in Atti Soc. Torino, XXXVI (1901), p. 68, and in Atti Soc. Ligust. XII (1901), p. 146; MASTERMAN Zool. (1901), p. 85, f. 27; G. S. WEST in Journ. Linn. Soc., Zool. XXVIII (1901), p. 309, and *op. cit.* XXIX (1903), p. 109; STOLC in Zeits. Allg. Physiol. I (1902), p. 209.

Amœba communis DUNCAN in Pop. Sci. Rev. XVI (1877), p. 233, tt. v, vi.

Amœba chaos LEIDY in Proc. Acad. Nat. Sci. Phil. 1878, p. 99.

In general aspect, as well as in size, extremely variable; endoplasm colourless or greyish granular, frequently containing desmids and other chlorophyllous algæ, or their remains, which have been incepted as food, also numerous refringent globules of variable size, and minute crystals of (apparently) calcium carbonate. Body when at rest irregularly spherical, or ovoid; but in motion exhibiting a tendency to differentiate into anterior and posterior extremities—lobate expansions being protruded anteriorly—or to form digitate pseudopodia, which sometimes develop short lateral branches; the posterior extremity often terminating in a protuberance, expansion, or mulberry-like bulb. Pseudopodal movements frequently very active; at times sluggish. The contractile vesicle (usually single) situated behind the nucleus, which is ovoid, with a punctated surface, and usually large and conspicuous.

Dimensions: Frequently 200 μ in diameter in the globular form, 300 × 150 μ when ovoid; radiate or dendroid, palmate, and cylindroid forms varying from 0·5 mm. to 1 mm. according to Leidy. Elongate variety (Pl. III, fig. 2), 400–450 μ.

In the ooze of ponds; amongst aquatic vegetation; also in marshes and bog-pools; abundant and universally distributed.

Amœba proteus was first described and figured by Rösel, under the name *Der kleine Proteus*, in his 'Insecten-Belüstigung' (Recreations amongst Insects), 1755. This was the first introduction to Naturalists of the Rhizopoda as a class. Three years later Linnæus embodied it in his 'Systema Naturæ,' ed. 10, calling it *Volvox chaos*; Pallas (1766) changed the name to *Volvox proteus*; and subsequently, under a variety of designations, each representing, no doubt, some one of the many forms assumed by the organism, it figured in the works of Continental authors. Ehrenberg, in his 'Infusionsthierchen' (1838), described the familiar large form as *Amœba princeps*, a name which it long retained; but Leidy, considering that *A. princeps* Ehrenb., and *Proteus diffluens* Müller—the original *Der kleine Proteus* of Rösel—represented one and the same animal, once more revised the nomenclature and adopted the title *Amœba proteus*, which is likely to be retained. Leidy remarks: "The specific name *proteus* (in *Volvox proteus* of Pallas) appears the more appropriate, and would at the same time serve to perpetuate the name given to the animal by its discoverer."

Amœba proteus, in one or more of its forms, must be familiar to every student of pond-life. It is to be found in all still ponds which contain healthy vegetation, either in the ooze at the bottom, about the older stems and leaves of aquatic plants, or in masses of floating algæ. During active movement the pseudopodia are usually digitate, simple or branched, of uniform thickness or tapering to a blunt apex; and the nucleus, which is invariably oval, is habitually posterior, the contractile vesicle occupying a position at no great distance behind it. Necessarily, however, during rapid movement, when the animal changes its line of march, forming pseudopodia first on one side, then on the other, the nucleus and vesicle get widely

separated, and their posterior position may be temporarily lost. According to Penard the elliptic, discoid, punctated nucleus is characteristic of this species.

In the larger examples of *Amœba proteus* the posterior ectoplasm habitually contracts, and, in doing so, forms a mass of "short digitate or mulberry-like processes." These, however, are not permanent. They appear to be modified or latent pseudopodia, which are, so to speak, grouped together and dragged behind by the animal in its progress. In some, and those always the largest individuals, they are conspicuous. Leidy's observations showed that they eventually get absorbed in the general mass, or, in response to some change in the creature's motion, develop into active pseudopodia and are used as such.

The endoplasm of *A. proteus* is usually charged with a considerable variety of extraneous material. Intermixed with chlorophyl-pellets there may be seen refringent bodies resembling oil-globules, and granules of starch. The former are probably adventitious substances, of no significance physiologically, though Leidy was of opinion that they might prove to be an intrinsic element. The starch-grains may have been incepted with the food. There are, in addition to these, minute crystals of quartz or calcium carbonate, or both, in variable quantity.

Although the food of *A. proteus* consists for the most part of chlorophyl-bearing algæ, such as diatoms and desmids, the animal, like others of its class, preys occasionally on other Protozoa, and even on the Rotifera.

Plate I, fig. 3, and Pl. III, f. 2, represent a remarkable variety, distinguished by its mulberry-shaped caudal extremity and finely-granular endoplasm. In the latter there is no admixture of oil-like globules or other adventitious matter, but green corpuscles are present, which in all the examples met with were of uniform size and very numerous. The nucleus and contractile vesicle are normally as in *A. proteus*, but in general aspect and mobility this form is so distinct as

to raise a doubt whether it really belongs to this species. Leidy, however, figures it as a form of *A. proteus* ('Freshw. Rhiz. N. Amer.', pl. i, fig. 4), and it may for the present be distinguished as var. *granulosa*.

It has been held that inasmuch as *A. proteus* reproduces by fission, the protoplasmic body may be divided, and propagation effected by artificial severance. This we think is more than doubtful. Gruber's investigation of the nucleus and its relation to the plasm, years ago, seemed to dispose of it. Deprived of the nucleus, says this observer, the plasma cannot sustain life. "The nucleus needs the plasm; the plasm the nucleus." Occasionally, though very rarely, an injured *Amœba* is met with, and the injury may result in the death of the individual. A case of this kind, which came within our own observation, has already been described (see pp. 28–29, f. 15).

2. **Amœba actinophora** Auerbach.

(Plate I, figs. 7–10.)

Amœba actinophora Auerbach in Zeits. f. wiss. Zool. VII (1856), p. 392, t. xx; Maggi in Rend. R. Ist. Lomb. (2) X (1877), p. 316; Gruber in Zeits. f. wiss. Zool. XXXVI (1881), p. 464, t. xxx, ff. 9–17, and (Engl. transl.) in Ann. Nat. Hist. (5) IX (1882), p. 110, t. ix, ff. 9–17; Bütschli Mikr. Schäume (1892), p. 73, t. ii, ff. 8, 9, and (Engl. transl.) Micros. Foams (1894), p. 107, t. iv, ff. 3, 4; Frenzel Mikr. Fauna Argent. I, Prot. 3 (1893), p. 89, t. viii, ff. 19, 20, and 4 (1897), p. 147, in Bibl. Zool. IV; Calkins Prot. (1901), p. 38.

? *Cochliopodium actinophorum* Penard Faune Rhiz. Léman (1902), p. 188, ff.

Plasma-body minute; when active resembling the smaller forms of *Cochliopodium bilimbosum*, with a rounded outline, from one side of which two to six (sometimes more) short, simple, or branching pseudopodia are protruded. According to Auerbach the protoplasm is "distinctly surrounded by a double contour," and the animal appears as if "covered by

an envelope" of thickened ectoplasm, which is capable of being absorbed or dissolved by the more fluent endoplasm, during pseudopodal extension, or on the assumption by the animal of a quiescent phase. In this latter phase the body becomes rounded or oval, or discoid, the granular endoplasm occupying a central position, with a translucent band of ectoplasm surrounding it. The animal in this condition is devoid of colour except from the presence of a few green particles contained in the endoplasm. It remains quiescent for an indefinite time.

Dimensions : Diameter when at rest (discoid phase), 30–40 μ.

In ponds, Cheshire, July, 1903.

The above specific characters are those given by Gruber (*loc. cit.*), with whose figures our Cheshire examples essentially agree, although the "double-contoured" character, said to be presented by the organism in the active state, was not apparent. The author cited remarks that the periphery, in his examples, was for the most part quite smooth, and that only at one point did the animal extend a larger or smaller number of lobed pseudopodia. There was, he says, no persistent membranous structure, but "during the flow of the animal the cortical layer became amalgamated with the rest of the sarcode." The body became flattened, and the "cortical zone" disappeared, its place being taken by a broad border of clear ectoplasm, which surrounded the darker and richly-granular central mass. In this state the nucleus becomes distinctly visible.

Gruber, at the time he recorded his observations, considered this organism to be identical with *Cochliopodium bilimbosum* Auerb., but the latter has a distinctly permanent, though very supple, hyaline envelope. Penard (*loc. cit.*) reunites *A. actinophora* with the genus *Cochliopodium*, remarking that it has a smoother envelope, which is also more delicate and

refringent, than that of *C. bilimbosum*. His figures, however (so different from Gruber's), create a doubt as to whether the organisms described by the two authors can have been identical.

3. **Amœba villosa** Wallich.

(Plate II.)

Amœba Wallich in Ann. Nat. Hist. (3) XI (1863), p. 287, t. viii (? excl. ff. 10 and 16).

Amœba villosa Wallich in Ann. Nat. Hist. (3) XI (1863), p. 336, t. ix, and p. 434, t. x, ff. 5–9; Barker in Q. J. Micr. Sci. VI, n.s. (1866), p. 125; Greeff in Sitz.-ber. Nat. Ver. Rheinl. XXIII (1866), p. 11; Tatem in M. Micr. Journ. I (1869), p. 353, and *op. cit.* VI (1871), p. 276, f.; Gagliardi in Q. J. Micr. Sci. XI, n.s. (1871), p. 80; Maggi in Rend. R. Ist. Lomb. (2) IX (1876), p. 439; Duncan in Pop. Sci. Rev. I, n.s. (1877), p. 233, t. vi, ff. 38–42; Leidy Freshw. Rhiz. N. Amer. (1879), p. 62, t. ii, ff. 14–16; t. viii, ff. 1–16; Hitchcock Synops. Freshw. Rhiz. (1881), p. 6; Gruber in Zeits. f. wiss. Zool. XLI (1885), p. 187; Lenderfeld in Proc. Linn. Soc. N. S. Wales, X (1885), p. 723; Whitelegge in Proc. Linn. Soc. N. S. Wales (2) I (1886), p. 499; Harvey in Amer. Nat. XXII (1888), p. 72; Mœbius in Abh. K. Akad. Wiss. Berlin, 1888 (1889), 2, p. 25, t. v, ff. 59, 60; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 46, t. ii, f. 1; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 56; Levander in Acta Soc. Fauna Fenn. XII (1894), no. 2, p. 10, t. i, f. 2; *op. cit.* XX (1901), no. 5, pp. 11, 22; and in Zool. Anzeig. XVII (1894), p. 209; Smith in Trans. Amer. Micr. Soc. XIX (1897), pp. 63, 69, and in Amer. M. Micr. Journ. XVIII (1897), p. 381; Rhumbler in Arch. f. Entwick. VII (1898), p. 125; Penard in Rév. Suisse Zool. VII (1899), p. 21, t. ii, ff. 1–3, and Faune Rhiz. Léman (1902), p. 70, ff.; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 309.

Amœba princeps (pars) Carter in Ann. Nat. Hist. (3) XII (1863), p. 30, etc., t. iii, ff. 1–3, 5.

Trichamœba hirta Fromentel Études Microz. (1874), p. 345, t. xxviii, f. 4.

Saccamœba villosa Frenzel Mikr. Fauna Argent. I, Prot. 1 (1892), p. 9, t. i, f. 4, and 4 (1897), p. 147, in Bibl. Zool. IV.

In size rivalling the larger forms of *Amœba proteus*, sometimes attaining, according to Wallich, a diameter of one-fiftieth of an inch. The body, at its posterior extremity, has a villous discoid or lobed protuberance, which, whilst capable of modification within certain limits, is persistent. Its precise function, however, is not evident. In all other respects the animal closely resembles, even in the young state, the larger forms of *A. proteus*. The nucleus and contractile vacuole are normally in the posterior region, the former ovoid and punctated like that of *A. proteus*, the punctulations being disposed longitudinally. Locomotion is effected by lobular expansions of the ectoplasm, anterior or lateral, or by digitate pseudopodia, which may emerge on one side (with the result of altering the line of progression) or from all sides at once, when the appearance shown in Pl. II, fig. 2, is presented. The villous appendage does not appear to be affected by any pseudopodal movements. The colour of the endoplasm is usually a creamy-white, greyish in the denser parts, granular, and containing green and other corpuscles resembling those observed in *A. proteus*, and not infrequently also desmids and other algæ.

Dimensions variable; elongated examples often attaining a length of 250 μ or more.

Ponds at Hampstead, 1863 (*Dr. Wallich*); in similar situations in Cheshire; in the Rossendale district of Lancashire (*J. E. Lord*); near Bingley, West Yorkshire (*G. S. West*).

Amœba villosa was first detected by Dr. Wallich in India, and he published a description of it in the 'Annals' (*l. c.*) in the year 1863. Returning to England he found it at Hampstead. We suspect, however, from Mr. H. J. Slack's description of some examples from the last-named locality, in the 'Intellectual Observer,' Vol. III, p. 430, that the much larger and coarser-looking organism, *Pelomyxa villosa* Leidy, was mistaken for it. The two species may have been

present, for they are found in similar situations, and not infrequently in the same water.

The villous appendage of *A. villosa* is capable of such modification as is shown by occasional contraction and expansion, but the villi always remain closely compacted, and apparently passive. Their appearance in the aggregate is that of a bundle of short threads; in this respect differing from the analogous organ in *Pelomyxa villosa* where the villi are thicker and shorter. Apart from these features the two organisms are not likely to be confounded, as they differ widely in the important matter of internal structure.

4. **Amœba gorgonia** Penard.

(Plate III, figs. 3–5.)

Amœba gorgonia Penard Faune Rhiz. Léman (1902), p. 78, ff.

Body when in repose globular, with a variable number of radiating mobile arms, outwardly extended on all sides, as represented in Pl. III, fig. 3. Penard observes that this attitude of the animal is induced by exposure to light. An individual, first met with in this condition, kept some of the pseudopodal arms moving constantly, until they disappeared under a sudden wave-like emission of ectoplasm. Upon this the animal began a forward movement, dragging behind it the remaining pseudopodia (fig. 4) which in their turn also became absorbed. Afterwards the animal rapidly underwent a series of modifications. One of the forms it assumed is represented by fig. 5. Our Cheshire examples exhibited all the peculiarities of structure described by Penard. The pseudopodia were cylindrical, of uniform thickness, and rounded at their extremities, never pointed as in some forms of *Dactylosphærium radiosum*. They were filled with the same granular endoplasm as the rest of the body (a feature regarded by Penard as of especial significance),

and differed widely from the hyaline pseudopodia of most of the lobose Rhizopods.

Dimensions: Average diameter of body (fig. 3) 40–50 μ; including pseudopodia about 100 μ.

In long-kept *Sphagnum* from Dunham, Cheshire, June, 1903.

In its movements this species is very rapid. It resembles, in some aspects, an exaggerated *A. limax*.

Within the endosarc there may be observed a variable number of brilliant granules, which in the resting-phase extend along the arms, even to their extremities, together with small vacuoles and chlorophyl corpuscles. The contractile vesicle and nucleus are small and inconspicuous; the latter is spherical.

5. **Amœba striata** Penard.

(Plate III, figs. 6 and 7.)

? *Amœba striolata* Perty Kenntn. kleinst. Lebensf. (1852), p. 188, t. viii, f. 15; Parona in Boll. Scient. I, an. 2 (1880), p. 24.

Amœba verrucosa (pars) Leidy Freshw. Rhiz. N. Amer. (1879), t. iii, f. 37.

Amœba striata Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 127, t. ii, ff. 31–34, and Faune Rhiz. Léman (1902), p. 127, ff.; Rhumbler in Arch. f. Entwick. VII (1898), pp. 123, 191, 262, ff. 38, 39, 66.

Body compressed, ovoid, narrowed and rounded posteriorly, but not exhibiting any caudal bulb or expansion. The nucleus round, posteriorly situated, a little in advance of the contractile vacuole, which attains a considerable size and is pellucid or pale bluish. The anterior region, when the animal is moving actively, consists of a broad expansion of clear ectoplasm. A characteristic feature of this organism is the presence of a series of delicate longitudinal lines (usually four) on the surface of the ectoplasm, which appear and disappear with the movements of the animal, indicating, in the opinion of Dr. Penard, the existence of an extremely fine pellicle.

The animal makes a slow but continuous advance, and during its movements the semi-fluid endoplasm flows longitudinally, in distinct streams, modifying, by pressure, the form of the contractile vacuole, which at one moment may be circular and the next elongated or irregularly outlined. The endoplasm is finely granular, colourless, or tinged with green from the presence of minute chlorophyl particles, and it contains also a limited number of larger granules or crystalline bodies of irregular shape.

Dimensions: Length 25–45 μ; greatest breadth anteriorly 20–35 μ.

In ponds amongst submerged vegetation, usually common.

The contractile vesicle, in this species, is curiously modified by the flow of the endoplasm. Whilst changing in position but slightly, its form exhibits constant variation. It will reappear, after discharge, sometimes as two separate vesicles of small size; these gradually enlarge, and ultimately unite; and the organ not infrequently presents an oval or distorted outline.

Amœba striata has been, by some, regarded as a young state of *A. verrucosa* Ehrenb. Leidy ('Freshw. Rhiz. N. Amer.') so describes and figures it. Apart from the fact that it is a much smaller organism, and possessed of characters of its own, which are constant, it is rarely found in association with *A. verrucosa* in the adult state.

6. **Amœba guttula** Dujardin.

(Plate V, fig. 4.)

Amiba guttula Dujardin Infus. (1841), p. 235; Crévier in Nat. Canad. VII (1875), p. 276.

Amœba guttula Perty Kenntn. kleinst. Lebensf. (1852), p. 188, t. viii. f. 13; Pritchard Hist. Infus. new ed. (1852), p. 203, and ed. 4 (1861), p. 549, t. xxii, f. 6; Auerbach in Zeits. f. wiss. Zool. (1856), p. 414, t. xxii, ff. 17, 18; Williamson in Pop. Sci. Rev. V (1886), p. 197,

t. xiii, ff. 17, 18; Czerny in Arch. f. Mikr. Anat. V (1869), p. 162; Tatem in M. Micr. Journ. I (1869), p. 352; Fromentel Études Microz. (1874), p. 347, t. xxiv, ff. 2, 3, 5; Géza in Herausg. Ungar. Nat.-Mus. Budapest, I (1877), p. 165; Bütschli in Bronn's Thier-Reichs, I, 1 (1880), t. ii, f. 3: Cooke in J. Quek. Micr. Club, vii (1880), pp. 105, 106; Parona in Boll. Scient. I, an. 2 (1880), p. 24, and *l. c.* an. 4 (1882), pp. 51, 56; Sacchi in Boll. Scient. III, an. 10 (1888), p. 41; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 132, t. iii, f. 2; in Rev. Suisse Zool. VII, 1 (1899), p. 100; and Faune Rhiz. Léman (1902), p. 38, ff.; Longi in Atti Soc. Ligust. V (1894), p. 14; Schewiakoff in Mém. Acad. Impér. Pétersb. (7) XLI, no. 8 (1893), p. 5; Rhumbler in Arch. f. Entwick. VII (1898), pp. 118, 126, 139.

Amæba guttula Maggi in Rend. R. Ist. Lomb. (2) IX (1876), p. 541.

Hyalodiscus guttula Blochmann Mikr. Thierw. Süsswass. (1886), p. 10, t. 1, f. 3, and ed. 2 (1895), p. 12, t. i, f. i; Delage & Hérouard Zool. concr. I (1896), p. 99.

Guttulidium guttula Frenzel Mikr. Fauna Argent. I, Prot. 4 (1897), p. 146, in Bibl. Zool. IV.

In general character resembling *A. limicola*, but shorter and broader in proportion to the length; during active movement ovoid and narrowed posteriorly, without any caudal protuberance, but in place of this with a few minute, nipple-like dentations occasioned by a contraction of the ectoplasm at that point. Movement effected by wave-like expansions of the ectoplasm, anterior or lateral. The granular endoplasm contains a variable number of crystalline and other particles, and occasionally minute diatoms. The anterior ectoplasm is faintly bluish or hyaline; the whole organism is transparent; the nucleus and contractile vesicle are normally situated, the former rounded, but susceptible of modification.

Dimensions: Length 30–35 μ; breadth 20–25 μ.

In ponds, amongst submerged vegetation, frequent.

This species was removed by Blochmann to Hertwig and Lesser's genus *Hyalodiscus*, but there is really no

affinity between it and the typical *Hyalodiscus rubicundus*. *Amœba guttula* is commonly met with amongst decaying vegetation, in ponds.

7. **Amœba limicola** Rhumbler.

(Fig. 16.)

Amœba limicola Rhumbler in Arch. f. Entwick. VII (1898), p. 145, etc., ff. 17, 22, and in Zeits. Allg. Physiol. II (1902), p. 183; Calkins Prot. (1901), pp. 81, 85, f. 15 a; Penard Faune Rhiz. Léman (1902), p. 40, ff.

Animal more or less globular, changing to oval or ellipsoid by expansions of the ectoplasm, such expansions being lobular, or formed by irruptions of the

Fig. 16.—*Amœba limicola*. × about 475.

internal plasma through the body-surface (hernia-like). Nucleus as in the preceding species.

Dimensions: Length 45–55 μ; average breadth about 35 μ.

Not common; occasionally met with in pools and sphagnum bogs.

The peculiar hernia-like pseudopodia, and the broad frontal expansions of the ectoplasm, are characters which seem to justify the separation of this from the preceding and other allied species. The pseudopodium, emanating from the surface of the body, resembles a miniature eruption. Through the breach made, the granular endoplasm, in its flow, recoils on either side upon the spherical body, instead of forming a digitate prolongation.

8. **Amœba limax** Dujardin.

(Plate III, fig. 1.)

Amiba limax Dujardin Infus. (1841), p. 235; Crevier in Nat. Canad. VII (1875), p. 276.

Amœba limax Perty Kenntn. kleinst. Lebensf. (1852), p. 188, t. viii, f. 12; Pritchard Hist. Infus. new ed. (1852), p. 203, and ed. 4 (1861), p. 549, t. xxii. ff. 4, 5; Auerbach in Zeits. f. wiss. Zool. VII (1856), p. 414, t. xxii, ff. 11–16; Carpenter Foram. (1862, *Ray Soc.*), p. 25; Tatem in M. Micr. Journ. I (1869), p. 352; Trinchese in Mem. Acc. Bologna, V (1875), p. 524; Géza in Herausg. Ungar. Nat.-Mus. Budapest, I (1877), p. 165; Bütschli in Bronn's Thier-Reichs, I, 1 (1880), t. ii, f. 2; Mikr. Schäume (1892), p. 72, t. i, ff. 10, 11; and (Engl. transl.) Micr. Foams (1894), p. 106, t. ii, ff. 7, 8; Cooke in J. Quek. Micr. Club, VI (1880), p. 105; Fullagar in Sci. Goss. 1880, p. 204, f. 134; Parona in Boll. Scient. I, an. 2 (1880), pp. 46, 48; Vejdovsky Thier. Org. Brunn. Prag (1882), p. 33, t. i, f. 1; Cattaneo in Boll. Scient. III, an. 10 (1888), p. 93; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 124, t. ii, ff. 1–5; in Arch. Sci. Phys. XXVI (1891), p. 137; in Rev. Suisse Zool. VII, 1 (1899), pp. 13, 100; and Faune Rhiz. Léman (1902), p. 35, ff.; Zoja in Rend. R. Ist. Lomb. (2) XXIV (1891), p. 987; Schewiakoff in Mém. Acad. Impér. Pétersb. (7) XLI, no. 8 (1893), p. 5; Delage and Hérouard Zool. concr. I (1896), p. 93, f. 96; Rhumbler in Arch. f. Entwick. VII (1898), p. 118 (*et passim*), ff. 30, 31; Calkins Prot. (1901), p. 80.

Hyalodiscus limax Blochmann Mikr. Thierw. Süsswass. (1886), p. 10, t. i, f. 4, and ed. 2 (1895), p. 12, t. 1, f. 2; Issel in Atti Soc. Ligust. XII (1901), pp. 146, 149; Levander in Acta Soc. Fauna Fenn. XX (1901), no. 6, p. 5.

Saccamœba limax Frenzel Mikr. Fauna Argent. I, Prot. 4 (1897), p. 147, in Bibl. Zool. IV.

Body elongated, slug-like, narrowed at the posterior extremity, where the plasma is more concentrated and rough, with a rounded protuberance, which in rapid movement develops a radiating fringe of very delicate substance. This fringed protuberance Penard regards as distinctive of the species. The body broadens

anteriorly, and the animal moves forward in an almost direct line, having a wide frontal margin of clear ectoplasm. The nucleus and contractile vesicle are in the posterior region, the latter usually in advance, and the endoplasm contains, besides food-particles, a variable number of minute crystalline bodies.

Dimensions : Length 50–60 μ; average breadth about 15 μ.

In ponds, etc., with *Amœba guttula*, and generally as plentiful.

This species is more active than *Amœba guttula*. Its mode of progression approaches that of some forms of *A. proteus* and *A. villosa*, but it is more uniform, and Penard points out its peculiar habit of changing the direction of its march by a movement of the anterior portion of the body *en masse*, to right or left, whilst the posterior remains stationary. This habit is certainly rare amongst the *Amœbæ*.

9. **Amœba verrucosa** Ehrenberg.

(Plate V, figs. 1–3.)

Amœba verrucosa Ehrenberg Infus. (1838), p. 126. t. viii, f. xi; Pritchard Hist. Infus. (1842), p. 166; new ed. (1852), p. 202; and ed. 4 (1861), p. 549; Perty Kenntn. kleinst. Lebensf. (1852), p. 188; Schmarda in Denkr. K. Akad. Wiss. Wien, VII (1854), 2, pp. 14, 25; Carter in Ann. Nat. Hist. (2) XX (1857), pp. 37, 40, t. i, ff. 12, 13; Pick in Ver. Vereins Wien, VII (1857), p. 36; Carpenter Foram. (1862, *Ray Soc.*), pp. 36, 39, t. iv, f. 8; Rymer Jones Anim. Kingd. ed. 4 (1871), p. 20; Fromentel Études Microz. (1874), p. 348, t. xxix, f. 7; Leidy in Proc. Acad. Nat. Sci. Phil. 1874, p. 167; *op. cit.* 1876, p. 198; *op. cit.* 1878, p. 158; and Freshw. Rhiz. N. Amer. (1879), p. 53, t. iii (excl. f. 37); Maggi in Rend. R. Ist. Lomb. (2) IX (1876), p. 441; Cattaneo in Boll. Scient. I, an. 1 (1879), pp. 7, 27, 57; *op. cit.* III, an. 10 (1888), p. 93; and in Atti Soc. Ital. XXII (1880), p. 254; Parona in Boll. Scient. I, an. 2 (1880), pp. 46, 48, and an. 4 (1882), pp. 51, 56; Hitchcock Synops. Freshw. Rhiz. (1881), p. 5; Vejdovsky Thier. Org.

Brunn. Prag (1882), p. 34, t. i, f. 2; Gruber in Zeits. f. wiss. Zool. XL (1884), p. 124, t. viii, f. 5, and *op. cit.* XLI (1885), p. 214, t. xv, ff. 39–48; Blochmann Mikr. Thierw. Süsswass. (1886), p. 10, t. i, f. 7, and ed. 2 (1895), p. 13, t. i, f. 4; Bolton in Midl. Nat. IX (1886), p. 174; Whitelegge in Proc. Linn. Soc. N. S. Wales, (2) I (1886), p. 499; Fielde in Proc. Acad. Nat. Sci. Phil. 1887, p. 122; Rolleston Forms Anim. Life, ed. 2 (1888). pp. 897, 899; Certes Cap. Horn Zool. VI (1889), Prot. p. 20; Mœbius in Abh. K. Akad. Wiss. Berlin, 1888 (1889), 2, p. 27, t. v, ff. 65, 66; Sacchi in Boll. Scient. III, an. 11 (1889), p. 67; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 128, t. ii, ff. 35–54; in Arch. Sci. Phys. XXVI (1891), p. 137; and in Rev. Suisse Zool. VII, 1 (1899), pp. 100, 104, 107; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 48; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 56; Schewiakoff in Mém. Acad. Impér. Pétersb. (7) XLI, no. 8 (1893), p. 5; Levander in Zool. Anzeig. XVII (1894), p. 209; in Acta Soc. Fauna Fenn. XII (1894), no. 2, p. 11, t. i, f. 1; *op. cit.* XX (1901), no. 5, pp. 11, 12; and *l. c.* no. 6, p. 5; Longi in Atti Soc. Ligust. V (1894), p. 15, and *op. cit.* VI (1895), p. 70; Dangeard in Le Botan. IV, 6 (1896), p. 202, ff. 1–5; Francé in Res. wiss. Erforsh. Balat. II (1897), p. 5; Scourfield in Proc. Zool. Soc. 1897, p. 787; Daday Mikr. Süsswass. Ceylon (1898), pp. 4, 9; Rhumbler in Arch. f. Entwick. VII (1898), p. 116 (*et passim*), ff. 1, 15, 25, 40, 41, 45–52, 58, 60–62, 65, t. vi, ff. A, C, F, and in Biol. Centralbl. XVIII (1898), p. 25, f. 1; Calkins Prot. (1901), p. 218, ff. 48, 118 d, 153; Issel in Atti Soc. Torino, XXXVI (1901), p. 68; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 309; *op. cit.* XXIX (1903), p. 109; and in Ann. Scott. Nat. Hist. 1905, p. 90.

Amiba verrucosa Dujardin Infus. (1841), p. 236; Crevier in Nat. Canad. VII (1875), p. 277.

Amœba natans Perty Kenntn. kleinst. Lebensf. (1852), p. 188, t. viii, f. 14.

Amœba quadrilineata Carter in Ann. Nat. Hist. (2) XVIII (1856), p. 243, t. v, f. 3; p. 248, t. vii, f. 81; and *op. cit.* (3) XIII (1864), p. 19; Pritchard Hist. Infus. ed. 4 (1861), p. 550; Carpenter Foram. (1862, *Ray Soc.*), p. 25; Barker in Q. J. Micr. Sci. IX, n.s. (1869), p. 94; Leidy in Proc. Acad. Nat. Sci. Phil. 1874, p. 167; *op. cit.* 1878, p. 158; and in Ann. Nat. Hist. (5) II (1878),

p. 271; Parona in Boll. Scient. I, an. 2 (1880), pp. 46, 48; Sacchi in Boll. Scient. III, an. 10 (1888), p. 41.

Amœba terricola Greeff in Arch. f. Mikr. Anat. (1866), p. 300, t. xviii; in Verh. Nat. Ver. Rheinl. XVII (1870), p. 201; and in Biol. Centralbl. XI (1891), p. 599; Trip in Proc. Bristol Nat. Soc. n.s. IV (1870), p. 14; Gagliardi in Q. J. Micr. Sci. XI, n.s. (1871), p. 80; Bütschli in Arch. f. Mikr. Anat. IX (1873), p. 676, t. xxi, f. 21; Maggi in Rend. R. Ist. Lomb. (2) X (1877), pp. 318, 321; Schneider in Compt. Rend. LXXXVI (1878), p. 1557; Du Plessis in Bull. Soc. Vaud. (2) XVI (1879), pp. 166, 325; Lanessan in Rev. Internat. Sci. VI (1880), p. 8, and Traité Zool. I (1882), p. 42; Parona in Boll. Scient. I, an. 2 (1880), p. 46; Gruber in Zeits. f. wiss. Zool. XL (1884), p. 123; Berthold Stud. Protopl.-mech. (1886), p. 109; Blochmann Mikr. Thierw. Süsswass. (1886), p. 10, t. i, f. 9, and ed. 2 (1895), p. 13; Binet Vie psych. in Psych. expér. (1888, 1891), p. 235; and (Engl. transl.) Psych. Life (1889), p. 114; Certes Cap. Horn Zool. VI (1889), Prot. p. 20; Sacchi in Boll. Scient. III, an. 10 (1889), p. 67; Hertwig Lehrb. Zool. 1 (1891), p. 149, and (Engl. transl. ed. 1900) Man. Zool. (1903), pp. 186, 189; Griffiths Physiol. Invert. (1892), p. 375; Longi in Atti Soc. Ligust. V (1894), p. 15; Penard Faune Rhiz. Léman (1902), p. 104, ff., and p. 666.

Thecamœba quadripartita Fromentel Études Microz. (1874), p. 346, t. xxxviii, f. 3.

Amœba verrucosa Maggi in Atti Soc. *Sci. Nat.* XIX (1876), p. 407, t. ix, ff. 1–3; in Rend. R. Ist. Lomb. (2) IX (1876), p. 541; and in Boll. Scient. I, an. 2 (1880), pp. 34, 81.

Amœba papillata Mereschkowsky in Arch. f. Mikr. Anat. XVI (1878), p. 203, t. xi, ff. 31, 32.

Saccamœba verrucosa Frenzel Mikr. Fauna Argent. I, Prot. 1 (1892), p. 4, t. iv, ff. 1, 2, and 4 (1897), p. 146, in Bibl. Zool. IV.

Body of the animal, when at rest, roughly spherical, oval, sub-quadrangular, or multilobate, always more or less rugose or verrucose. Forward movement effected by extensions of short anterior pseudopodia, or by broad wave-like expansions of the ectoplasm, which changes are accompanied by a wrinkling of the surface, resulting in the production of more or less regular longitudinal striations, very fine but distinctly

perceptible. Endoplasm granular, sub-transparent, containing a spherical nucleus, and (in the posterior region) a contractile vacuole, which is usually conspicuous, together with a variety of food-remains, animal or vegetable, or both. Habit very sluggish.

Dimensions variable. Average length, during rapid march, about 200 μ. (Maximum 300–350 μ, Greeff.)

In the ooze of ponds, amongst submerged vegetation, in tufts of moss growing on moist rocks, and in marshy places; widely distributed, but less common than *A. proteus*.

The characters and habit of *Amœba verrucosa* separate it distinctly from every other member of the genus. The crinkled or striated ectoplasm is indicative of an unusual degree of surface-hardening, but cannot be regarded as evidence of a permanent envelope. The lines are often numerous and extremely delicate, extending longitudinally from the vicinity of the contractile vesicle forward to the anterior ectoplasm. They are most distinct at or near the margins where the protoplasm is least dense. The short, blunt, and generally very persistent wart-like protuberances on the surface of the body are a further distinctive feature. Pseudopodal movement is slow in this animal.

A. verrucosa is an omnivorous feeder. Besides desmids and other algæ, individuals are sometimes found which contain the half-digested remains of infusorians and rotifers. (Pl. IV, fig. 1.)

Some observers (*e. g.* Leidy in 'Freshw. Rhiz. N. Amer.') have regarded what has since been described as *A. striata* Penard, as a young state of the species under notice—probably on insufficient grounds. The young of *A. verrucosa*, which we have sometimes met with, is normally a sub-spherical pellucid body (Pl. V, figs. 1 *a*, *b*, *c*), containing some granular, almost colourless endoplasm, and furnished with a nucleus and contractile vesicle. There is the wrinkled envelope of hyaline ectoplasm, extremely delicate, but clearly

outlined. The figures show the successive phases presented by an individual, 1 *c* exhibiting a distinct approach to the mature form of *A. verrucosa* by the production of one or two of the characteristic verrucose protuberances. The movements of the organism were extremely slow.

A good deal of confusion has arisen regarding *A. verrucosa* Ehrenb., and *A. terricola* Greeff. Leidy, and more recently Penard, regarded the two as synonymous. Blochmann, whilst maintaining the specific claims of *A. terricola*, gives, in 'Die Mikros. Thierw. des Süsswassers,' a figure which represents the resting-phase, as we have seen it, of *A. verrucosa*. These animals are subject to great variation. Carter, who first described the minute *A. quadrilineata*, subsequently arrived at the conclusion that it was a young state of *A. verrucosa*.* In this Leidy and others concurred. The latter author also, in the series of forms which he figured, included what Penard has since distinguished as *A. striata*. In *A. verrucosa* Ehrenb., Blochmann includes *A. quadrilineata* Carter (80–100 μ), and he maintains *A. terricola* Greeff (350 μ) as a separate species. For the present, and until ambiguities have been removed, we consider it safer to make *A. terricola* synonymous with the original *A. verrucosa* of Ehrenberg.

10. **Amœba pilosa** Cash.

(Plate IV, figs. 1–5.)

Amœba pilosa Cash, in Journ. Linn. Soc., Zool. XXIX (1904), p. 219, t. xxvi, f. 8.

Animal somewhat resembling an average-sized *Amœba villosa*, with the same pale-bluish or neutral-tinted, finely granular protoplasm, and containing, as in that species, a variety of corpuscles, mostly chlorophyllous, together with refringent yellowish or brownish oil-like globules. Nucleus pale; contractile vesicles

* 'Ann. & Mag. Nat. Hist.,' (2) xx (1857), p. 37.

one or more. The posterior extremity is produced into a delicately-fringed extension of faintly granular protoplasm, in which are usually to be seen one or two small vacuoles. Its external outline is irregular, with a tendency to become lobate. The entire body of the animal, including the posterior expansion, is covered with delicate spicules, radiating outwards, of equal length, and closely resembling those which invest the membranous test of *Cochliopodium vestitum*. This latter character at once distinguishes *A. pilosa* from all other known forms of *Amœba*. Locomotion is effected by lobular expansions of the ectoplasm, anterior or lateral. As in *A. proteus* and *A. villosa* the pseudopodia may originate at any point of the body-surface. They have never been observed to become digitate.

Dimensions: Length about 180 μ; average breadth 50 μ.

In ponds at Chelford, Cheshire, amongst floating vegetation; associated with *Mastigamœba aspera* Schulze, *Ciliophrys infusionum* Cienk., etc.; June, 1903. In similar situations at Fearnhead, Lancashire.

It is difficult to explain the origin and purpose of the delicate processes which so completely invest the body of this animal. Careful observation showed that upon the formation of a pseudopodal lobe, or broad eruptive expansion of the ectosarc, the spicules instantly flowed over it from the surrounding surface; the continuity of the investment was thus ensured during all the animal's movements.

The Fearnhead examples of *A. pilosa* presented some differences from the typical Chelford form. They were probably older individuals. The investiture was the same, but it was observed that the individual spicules were stouter, and many of them were darker in colour, assuming often a yellowish-brown hue, whilst the endoplasm of the animal was denser. The posterior expansion was entirely wanting, and the animal was much less active.

Genus 2. **DACTYLOSPHÆRIUM** Hertwig & Lesser, 1874.

Amœba (pars) Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1830 (1832), p. 39, and Infus. (1838), p. 128.
Dactylosphærium Hertwig & Lesser in Arch. f. Mikr. Anat. X (1874), Suppl., p. 54.

Body amœboid; distinguished from *Amœba* by the possession, during the quiescent phase, of rigid or but slightly flexuose pseudopodia, which radiate irregularly from the sub-globular body-mass, and are variable in number and length. Pseudopodal movements slow, the pseudopodia often immobile for long periods; endoplasm as in *Amœba*, generally colourless or only slightly tinged with green, except in *D. polypodium*. The latter, in the density and colour of its endoplasm, approaches *Mastigamœba*.

The rigid and frequently elongated and pointed pseudopodia (in the resting-phase) mainly characterize this genus. *D. radiosum* is truly amœboid in the active phase.

1. **Dactylosphærium radiosum** (Ehrenb.) Bütschli.

(Plate III, figs. 8–11; Pl. IV, figs. 6–11.)

Amœba radiosa Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1830 (1832), p. 39; *op. cit.* 1831 (1832), p. 80; and Infus. (1838), p. 128, t. viii, f. xiii; Pritchard, Nat. Hist. Animalc. (1834), p. 38; Hist. Infus. (1842), p. 166, t. ii, f. 88; new ed. (1852), p. 202, t. ii, f. 88; and ed. 4 (1861), p. 549, t. xxii, ff. 1–3; Perty Kenntn. kleinst. Lebensf. (1852), p. 188; Cole in Proc. Essex Inst. I (1853), p. 45; Schmarda Grundz. Zool. I (1853), p. 26, f. 15; Auerbach in Zeits. f. wiss. Zool. VII (1856), p. 400, t. xxi; Pick in Verh. Vereins Wien, VII (1857), p. 36; Carpenter Foram. (1862, *Ray Soc.*), p. 24, t. i, f. 15; t. iv, ff. 6, 7; Carus Handb. Zool. II (1863), p. 591; Wallich in Ann. Nat. Hist. (3) XI (1863), p. 443; Williamson in Pop. Sci. Rev. V (1866), p. 197, t. xiii, ff. 14–16; Czerny in Arch. f.

mikr. Anat. V (1869), p. 161; Rolleston Forms Anim. Life (1870), p. 257, t. xii, f. 9; Greene Man. Prot. (1871), p. 4, f. 1; Maggi in Atti Soc. Ital. XIX (1876), p. 407, and in Rend. R. Ist. Lomb. (2) XXI (1888), p. 308; Géza in Herausg. Ungar. Nat.-Mus. Budapest, I (1877), p. 166; Cattaneo in Atti Soc. Ital. XXI (1878), p. 31, and in Boll. Scient. I, an. 1 (1879), p. 7; Leidy Freshw. Rhiz. N. Amer. (1879), p. 58, t. iv, ff. 1–18, and in Proc. Acad. Nat. Sci. Phil. (1879), p. 163; Leuckart in Boll. Scient. I, an. 1 (1879), p. 14; Fullagar in Sci. Goss. 1880, p. 204, f. 127; Mereschkowsky in Arch. f. mikr. Anat. XVI (1880), p. 200, t. xi, ff. 33–35; Parona in Boll. Scient. I, an. 2 (1880), p. 24, and *l. c.* an. 4 (1882), pp. 51, 56; Hitchcock Synops. Freshw. Rhiz. (1881), p. 5; Nicholson Classif. Anim. Kingd. (1882), p. 5, f. 3B, and Man. Zool. ed. 7 (1887), p. 76, f. 17B; Bolton in Midl. Nat. IX (1886), p. 174; Whitelegge in Proc. Linn. Soc. N. S. Wales, (2) I (1886), p. 449; Fielde in Proc. Acad. Nat. Sci. Phil. 1887, p. 122; Harvey in Amer. Nat. XXII (1888), p. 72; Meissner in Zeits. f. wiss. Zool. XLVI (1888), p. 505; Sacchi in Boll. Scient. III, an. 10 (1888), p. 42, and *l. c.* an. 11 (1889), p. 67: Certes Cap. Horn Zool. VI (1889), Prot. p. 20; Mœbius in Abh. K. Akad. Wiss. Berlin, 1888 (1889), 2, p. 25, t. v, ff. 52–54; Cuneo in Boll. Scient. III, an. 12 (1890), p. 142; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 131, t. ii, ff. 73–76; t. iii, f. i; in Rev. Suisse Zool. IX (1901), p. 237; and Faune Rhiz. Léman (1902), p. 86, ff.; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 94; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 48, t. ii, f. 28; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 56; Jelliffe in Amer. M. Micr. Journ. XIV (1893), p. 289; Longi in Atti Soc. Ligust. V (1894), p. 16; Scourfield in Proc. Zool. Soc. 1897, p. 787; Rhumbler in Arch. f. Entwick. VII (1898), pp. 144, 198, f. 16; Monti in Rend. R. Ist. Lomb. (2) XXXII (1899), p. 161; Calkins Prot. (1901), p. 80; Issel in Atti Acc. Torino, XXXVI (1901), pp. 68, 70.

Amiba radiosa Dujardin in Ann. Sci. Nat. IV (1836), p. 237, and Infus. (1841), p. 236, t. iv, ff. 2, 3; Schoch Mikr. Thiere Süsswass. I (1868), p. 10, t. i, f. 17; Bergonzini in Atti Soc. Nat. Modena, Rend. I (1882), p. 22.

Amiba brachiata Dujardin Infus. (1841), p. 238, t. iv, f. 4.

Amœba brachiata Fromentel Études Microz. (1874), p. 347, t. xxix, f. 4; Cattaneo in Boll. Scient. I, an. 3 (1882),

p. 116, and *op. cit.* III, an. 10 (1888), p. 91; Sacchi in Boll. Scient. III, an. 10 (1888), p. 41.

Amæba radiosa Maggi in Rend. R. Ist. Lomb. (2) IX (1876), p. 511, and in Boll. Scient. I, an. 2 (1880), p. 35.

Astramœba radiosa Vejdovsky in Sitz.-ber. K. Böhm. Ges. Wiss. 1880 (1881), p. 138, and Thier. Org. Brunn. Prag (1882), p. 36, t. i, f. 6.

Dactylosphæria radiosum Bütschli in Bronn's Thier-Reichs, I, 1 (1880), t. i, f. 10.

Dactylosphæria radiosa Lanessan Traité Zool., Prot. (1882), p. 47, f. 34; Bergonzini in Atti Soc. Nat. Modena, Memor. (3) II (1883), p. 73.

Dactylosphærium radiosum Blochmann Mikr. Thierw. Süsswass. (1886), p. 11, t. i, f. 10, and ed. 2 (1895), p. 14, t. i, f. 6; Frenzel Mikr. Fauna Argent. I, Prot. 1 (1892), p. 32, t. i, f. 5, and 4 (1897), p. 148, in Bibl. Zool. IV; Delage & Hérouard Zool. concr. I (1896), p. 99, f. 106; Francé Result. Erfors. Balatons. II, 1 (1897), p. 6; Levander in Acta Soc. Fauna Fenn. XX (1901), no. 6, p. 5; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 310, t. xxviii, ff. 4, 5; *op. cit.* XXIX (1903), pp. 109, 113, t. xiii, ff. 1, 2; and in Ann. Scott. Nat. Hist. 1905, p. 81.

Animal small and generally inactive, globular or oval in outline, and exhibiting three or more—in some individuals as many as six or eight—pseudopodia, which frequently take the form of immobile arm-like projections varying in length and degree of rigidity. They may be short and stumpy, tapering from a broad base, or elongated to several times the diameter of the body, of nearly equal width throughout and blunt at the apex, or long, straight, and tapering acutely. As a rule they radiate from all parts of the body-surface, and remain for long periods without perceptible change. In this condition the animal is quite passive, floating in the water or driven about by currents. The body consists of granular protoplasm, and when all the pseudopodia are withdrawn it may become subspherical or bluntly lobed; or it may assume an active amœboid phase, when it is hardly, if at all, distinguishable from the smaller forms of *Amœba proteus*. Chlorophyllous food is taken during the periods of activity.

Dimensions variable : diameter of body usually about 30 μ ; length of pseudopodia sometimes 120 μ, or over.

In marshes and pools, amongst submerged vegetation, and in moss on dripping rocks ; less common than *Amœba proteus*, with which it is often associated.

The rayed disposition of the pseudopodia and their rigid habit are characteristic of this species. Frequently the arms are curved, bent at an angle, or waved. A pseudopodium in extending or retracting will sometimes assume a spiral form and remain rigid in that attitude indefinitely. The endoplasm, as a rule, is uniformly granular, and the chlorophyllous matter occupying it is sparser than in the common *Amœbæ*.

Bütschli transferred this form to the genus *Dactylosphærium* (which he named in error *Dactylosphæria*), though it must be confessed that there are few points of affinity between it and *D. polypodium*, so that there is some ground for Vejdovsky's view that it should form the type of a new genus which he named *Astramœba*. Penard, however ('Faune Rhiz. du Bass. du Léman'), does not consider that either *Dactylosphærium radiosum* or *D. polypodium* should be separated from the true *Amœbæ*.

2. **Dactylosphærium polypodium** (Max Sch.) Bütschli.

(Plate III, fig. 12; Pl. IV, fig. 12.)

Amœba polypodia Max Schultze Organism. Polythal. (1854), t. viii, f. 21 ; F. E. Schulze in Arch. f. mikr. Anat. XI (1875), p. 592, t. xxxvi ; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 276 ; Claus Lehrb. Zool. (1885), ff. 11, 134, and (Engl. transl.) Text-book Zool. I (1884), p. 22, ff. 11, 121 ; Gruber in Zeits. f. wiss. Zool. XI (1884), p. 128 ; Maggi in Rend. R. Ist. Lomb. (2) XXI (1888), p. 306 ; Hertwig Lehrb. Zool. I (1891), p. 149, f. 116 ; ed. 2 (1900), p. 160, f. 114 ; and (Eng. transl.) Man. Zool. (1903), p. 189, f. 119 ; Sedgwick Text-book Zool. I (1898), p. 4, f. 2 ; Jordan & Kellog Anim. Life (1900), p. 8, f. 4 ; Calkins Prot. (1901), p. 80.

Dactylosphærium vitreum Hertwig & Lesser in Arch. f. mikr. Anat. X (1874), Suppl. p. 54, t. ii, f. 1a (*non* 1b); Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 266, f. 1; Archer in Q. J. Micr. Sci. XVII, n. s. (1877), p. 344, t. xxi, f. 17; Parona in Boll. Scient. II, an. 6 (1884), p. 56; Blochmann Mikr. Thierw. Süsswass. (1886), p. 11, t. i, f. 10, and ed. 2 (1895), p. 14, t. i, f. 7; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 310.

Dactylosphæria polypodia Bütschli in Bronn's Thier-Reichs, I, 1 (1880), t. i, f. 11.

Dactylosphærium polypodium Lanessan Traité Zool., Prot. (1882), p. 48, f. 35.

Dactylosphæra polypodia Ray Lankester in Encycl. Brit. ed. 9, XIX (1885), p. 842, f. iv, 1–3; Longi in Atti Soc. Ligust. (1894), p. 16; Delage & Hérouard Zool. concr. I (1896), p. 99, f. 107.

Amœba vitrea Penard Faune Rhiz. Léman (1902), p. 84, ff.

According to the description given by Hertwig and Lesser this species has a spherical or sub-spherical body, from which radiate blunt or conical pseudopodia, in length usually about half the diameter of the body, and, like the border, consisting of a "perfectly homogeneous, quite clear, glassy-looking plasma." Immersed in the protoplasm are a great number of greenish, strongly-refractive granules, varying in size. Two forms of the organism are described, one being green, the other a bright clear yellow. The coloured elements are crowded, filling the body-mass all but the narrow hyaline border, and preventing any view of the nucleus. In most, if not all, of the examples of the green form met with by Hertwig and Lesser, the entire superficies, including the pseudopodia, was covered by "peculiar protoplasmic hair-like prolongations, in which, however, no movement was perceptible." Amongst other points of distinction Hertwig and Lesser say that the green examples lay motionless and at rest, appearing as more or less regular balls, and only these, with their numerous projected pseudopodia, showed a slow forward or backward movement. With the yellow-coloured individuals the case was different. These not only moved with comparative rapidity, aided

by their quickly-projected, mostly numerous pseudopodia, but even their body-mass took an active share in locomotion, similar to that of *Amœbæ*.

Dimensions: Diameter of body (without pseudopodia) 6–12 μ.

Various localities in Cheshire. Shelf, West Yorkshire (*G. S. West*). Chipperfield, Herts (*A. Earland*).

The genus *Dactylosphærium* was established by Hertwig and Lesser to receive the organism named by them *Dactylosphærium vitreum*. One form of this appeared to be closely allied to, if not identical with, forms of *Mastigamœba aspera* F. E. Schulze. Mr. John Hopkinson has been at considerable pains recently to investigate the relationships of the different forms described by these authors, and has come to the conclusion that the species which we here refer to *Dactylosphærium polypodium*, is the same organism as *Amœba polypodia* Max Sch. and F. E. Sch., and also *Dactylosphærium vitreum* Hertw. & Less., t. ii, f. 1A (the yellow form), whilst *Dactylosphærium vitreum* Hertw. & Less., t. ii, f. 1B (the green form) referred to in the preceding pages, although much like some forms of *Mastigamœba aspera*, is a distinct species to which the name *D. vitreum* should be restricted.

Lanessan, in ' Traité de Zool., Protozoaires ' (1882), distinguishes between *Dactylosphærium polypodium* Max Sch. sp., and *D. vitræum* Hertw. & Less., indicating characters for the latter which are strictly those of Hertwig and Lesser's f. 1B, and likewise consistent with what we have observed in *Mastigamœba aspera*.

Genus 3. **MASTIGAMŒBA** F. E. Schulze, 1875.

Mastigamœba F. E. Schulze in Arch. f. mikr. Anat. XI (1875), p. 583.

Animal amœboid in structure and habit; during progression elongated, elliptic or ovoid; the body

narrowed anteriorly, and forming a conical lobe or prominence from which emanates a long and active flagellum. Pseudopodia short, radiating outwards from the cortical ectoplasm, simple or ramulose. The body-surface, in at least one species, is habitually covered with minute bacilliform spiculæ.

1. **Mastigamœba aspera** F. E. Schulze.

(Plate VI, figs. 1–5.)

Mastigamœba aspera F. E. Schulze in Archiv. f. mikr. Anat. XI (1875), p. 583, t. xxxv; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 268, f. 3; Archer in Q. J. Micr. Sci. XVII, n.s. (1877), p. 350, t. xxi, f. 24; Kent Man. Infus. I, pt. 2 (1880), p. 221, t. i, f. 21; Lanessan Traité Zool., Prot. (1882), p. 50, f. 38; Bütschli in Bronn's Thier-Reichs, I, 2 (1883), t. xxxix, f. 9; Griffiths & Henfrey Micr. Dict. ed. 4 (1883), p. 492, t. liii, f. 22; Hertwig Lehrb. Zool. I (1891), p. 147, f. 43; ed. 2 (1900), p. 159, f. 113; and (Engl. transl.) Man. Zool. (1903), p. 188, f. 118; Calkins Prot. (1901), p. 103, f. 57A.

Animal, in the resting phase, sub-spherical or oval, ultimately, when in active movement, becoming elongated and narrowed anteriorly, whilst the posterior extremity remains rounded, or, in what may be younger individuals, is produced into a rounded lobe. The body is susceptible of considerable modifications, changing from globular to oval, or becoming bluntly angular, whilst throwing out numerous amœboid pseudopodia, in which condition the organism is hardly distinguishable from some forms of *Amœba*, except by its highly-refringent and denser protoplasm. In the mobile state (Pl. VI, fig. 1) the pseudopodia are numerous, variable in length, usually simple and straight, rarely bigeminate or forked, mostly attenuated but blunt at the apex, and never becoming filamentous or acicular. The posterior ones are short; those immediately in front, on either side of the frontal lobe, longer and

narrower, and generally pellucid. The arrangement of the pseudopodia, in this aspect of the animal, is fairly regular: they extend outwards from the margins of the compressed body, being, in fact, extensions of the ectoplasm, and appear to occupy a common plane. The refringent character of the ectoplasm extends also to the pseudopodia, and is heightened by the presence of innumerable minute spiculæ which adhere to the surface tangentially or horizontally. The nucleus is single, imbedded in the anterior ectoplasm just behind the frontal lobe, and is sometimes hidden by the semi-opaque granular endoplasm. From this lobe the flagellum extends outwards, its point reaching beyond the extremities of the pseudopods; it is hyaline, very refractive, and always alert, moving and coiling with great rapidity; from which circumstance it is not infrequently difficult of detection. Contractile vesicles, usually two, on opposite sides of the body, in the posterior region.

Dimensions variable: length averaging 150–200 μ; average breadth about 50 μ.

In the ooze of ponds, and amongst floating vegetation, at Chelford and Northenden, Cheshire; and at Fearnhead, Lancashire.

The facial aspect of *Mastigamœba aspera* differs remarkably from that of the larger *Amœbæ* with which it might be confounded. It attracts attention at once by its refringent protoplasm. The flagellum, its peculiarly-distinctive feature, is stated by F. E. Schulze to be 0·06–0·08 mm. long, and is rightly described by him as "a very fine filament of equable but hardly-defineable character, and considerable refractive power." It is not attenuated at the extremity but of equal thickness throughout, and ends "as if abruptly cut off." The movements of the animal are distinctly amœboid; the action of the flagellum has no effect as an organ of locomotion, though in very young and small individuals its rapid movements do seem at times to

produce a slight jerky motion of the body from side to side.

The nucleus is prominently situated, appearing in some individuals as an irregularly-rounded body, strongly refractive, and about 9 μ in diameter. Schulze remarks that it is surrounded by a clear space, and that within its substance may be detected "a number of minute globular, sharply-bounded clear spots, which have the power of altering their positions."

Usually two contractile vacuoles may be observed imbedded in the densely-granular protoplasm near the periphery, on each side. Their pulsations appear to be very languid.

The bacilliform spicules, of which mention has been made, line the outer surface of the body in a thin stratum, apparently imbedded in a mucous film. They vary in number; in some individuals so few as to be hardly perceptible; in others thick enough to justify the specific name given to the organism.

In water from a pond at Northen Etchells, Cheshire, about the end of June, a form of *Mastigamœba* occurred which presented a remarkable variation from the type. The posterior extremity, instead of being broadly rounded, formed a circular expansion of ectoplasm, finely granular, containing some small vacuoles, and fringed with short radiating conical or acute pseudopodia, of very delicate structure. A few minute spicules could be detected on the surface of this appendage, but neither on the body nor on the pseudopodia proper were any visible. The pseudopodia, in these abnormal examples, were more attenuated and fewer in number than in the others, and at the same time more pellucid. The flagellum was active in most cases, seeming to perform the function of a tentacle. The individuals were comparatively small, and generally lighter in colour, and they had a wider margin of ectoplasm. For the present we retain this (Pl. VI, f. 4) as a variety—*M. aspera*, var. *cestriensis*.

2. **Mastigamœba ramulosa** Kent.

(Plate VI, fig. 6.)

Mastigamœba ramulosa Kent Man. Infus. I, pt. 2 (1880), p. 222, t. i, ff. 19, 20.

Body during active movement elongate-ovate, about one and a half times longer than broad, the entire peripheral surface bearing sub-equal branched pseudopodal prolongations. Neither these nor the general surface of the body show secondary hispid pseudopodia. The flagellum exceeds the body in length. The nucleus is sub-central and spherical; the contractile vesicle is located posteriorly.

Dimensions: Length (according to Saville Kent) 1–400″ (63 μ).

In marsh-water, as yet only met with in Jersey (*Kent*).

The description of this organism is from Kent's 'Manual of the Infusoria.' The author says that the conspicuously-branched character of the abundant pseudopodia serves to distinguish it readily from other forms, and communicates to it, as a whole, an aspect suggestive of a minute Nudibranch. Under any disturbing influence the little animal immediately contracts into a sub-spheroidal contour. It was observed that the granule-circulation, conspicuously indicated in the centre substance of the body, did not extend into the branched pseudopodia, nor were these appendages withdrawn entirely within the periphery at any time.

Genus 4. **PELOMYXA** Greeff, 1874.

Pelobius * Greeff in Verh. nat. Ver. Rheinl. XXVII (1870), pp. 198, 200.
Pelomyxa Greeff in Arch. f. mikr. Anat. X (1874), p. 51.

Amœboid rhizopods mostly of large size with a hyaline ectoplasm and granular semi-fluid endoplasm,

* Pre-occupied in Coleoptera.

the latter usually containing large quantities of extraneous matter and miscellaneous food particles, and always numerous clear corpuscles (the *glanzkörper* of German naturalists) regarded by the earlier observers as zoospores, but more recently proved to be albuminoid, and probably a source of nourishment to the symbiotic bacteria with which the body of the organism is charged.* Nuclei in some species very numerous and minute; in others of the ordinary type, and fewer; contractile vacuole absent, its place being apparently taken by numerous small watery-looking vacuoles dispersed through the endoplasm. Locomotion effected by broad lobular or wave-like expansions of the frontal ectoplasm, or by pseudopodia originating on any part of the surface, the posterior extremity during active movement appearing rounded, and being furnished with short sub-persistent hyaline pseudopodia, or with a spherical lobe of granular structure (less dense than the substance of the body), the surface of which is covered with villous processes.

1. **Pelomyxa palustris** Greeff.

(Plate VII, figs. 1–3.)

Pelomyxa palustris Greeff in Arch. f. mikr. Anat. X (1874), p. 51, tt. iii–v; F. E. Schulze in Arch. f. mikr. Anat. XI (1875), p. 342, t. xix, ff. 6–8; Gabriel in Morph. Jahrb. I (1876), p. 541; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 271, f. 5; Archer in Q. J. Micr. Sci. XVII, n.s. (1877), p. 337, t. xxi, ff. 10–15†; Engelmann in Arch. ges. Physiol. XIX (1879), p. 1; Bütschli in Bronn's Thier-Reichs, I, 1 (1880), t. ii, f. 1; Mikros. Schäume (1892), p. 216; and (Engl. transl.) Micros. Foams (1894), p. 116; Korotneff in Arch. Zool. expér. VIII (1880), p. 476, t. xxxvi, ff. 6–23; Lapham in Amer. Journ. Micr. V (1880), pp. 165, 197; Lanessan Traité Zool., Prot. (1882), p. 44, ff. 32, 33; Ray Lankester in Encycl. Brit. ed. 9, XIX (1885), p. 842, f. iv, 5, 6; Berthold Stud. Protopl.-mech. (1886), p. 109, t. ii, f. 6; Blochmann Mikr. Thierw.

* Mrs. L. J. Veley, in 'Journ. Linnean Soc.,' Zool., vol. xxix, pp. 375-386.

† As *P. lacustris* in Zool. Rec. for 1877, Prot. p. 4.

Süsswass. (1886), p. 10, t. i, f. 9; ed. 2 (1895), p. 13, t. i, f. 5; and in Biol. Centralbl. XIV (1894), pp. 86, 115; Whitelegge in Proc. Linn. Soc. N. S. Wales, (2) I (1886), p. 499; Gulliver in Journ. R. Micr. Soc. 1888, p. 11; Meissner in Zeits. f. wiss. Zool. XLVI (1888), p. 505; Verworn Psychophys. Prot. Stud. (1889), pp. 40, 161, etc., t. iv, f. 13; Bourne in Quart. Journ. Micr. Sci. XXXII, n.s. (1891), p. 362, etc., Hertwig Lehrb. Zool. I (1891), p. 149; ed. 2 (1900), p. 160; and (Engl. transl.) Man. Zool. (1903), p. 189; Voeltzkow in Zool. Anzeig. XIV (1891), p. 228; Penard in Arch. Sci. Phys. XXIX (1893), p. 165; in Rev. Suisse Zool. VII, 1 (1899), p. 18; *op. cit.* VIII (1900), p. 486; *op. cit.* IX (1901), p. 238; and Faune Rhiz. Léman (1902), p. 139, ff.; Shipley Zool. Invert. (1893), p. 10, f. 3; Gould in Q. J. Micr. Sci. XXXVI, n.s. (1894), p. 295, tt. xx, xxi; Levander in Acta Soc. Fauna Fenn. (1895), no. 2, p. 12; Delage & Hérouard Zool. concr. I (1896), p. 100, f. 112; Prowazek in Biol. Centralbl. XVII (1897), p. 881; Rhumbler in Arch. f. Entwick. VII (1898), p. 118, f. 2, t. vi, f. B; Monti in Rend. R. Ist. Lomb. XXXII (1899), p. 161; Stolc in Zeits. f. wiss. Zool. LXVIII (1900), p. 625; Wilson in Amer. Nat. XXXIV (1900), p. 543, etc.; Calkins Prot. (1901), p. 95; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 309, and *op. cit.* XXIX (1903), pp. 109, 112; Cash in Journ. Linn. Soc., Zool. XXIX (1904), p. 218; Veley in Journ. Linn. Soc., Zool. XXIX (1905), p. 374, tt. xxxvi-xxxviii, f. on p. 391.

? *Amœba princeps* Czerny in Arch. f. mikr. Anat. V (1869), p. 159.*

? *Amœba proteus* Brayley in Sci. Goss. 1886, p. 19.*

Body of large size, presenting during active movement a rounded, oval, or elongated figure, often broadly lobed and irregular. Adult individuals opaque, from the presence in the colourless endoplasm of an extraordinary quantity of incepted matter, consisting of mud, sand-particles, and decayed vegetable *débris*; bounded externally by a thin layer of finely-granular or hyaline ectoplasm. With the other contents, there may often be observed various organisms which have been taken as food (enclosed in large vacuoles)

* Described as abnormally large forms of the species to which they were referred.

including desmids and other algæ, and sometimes also rotifers and entomostraca.

Such a mass of foreign matter renders a study of the physiological structure of this organism difficult in adult individuals; but in younger examples, sometimes though rarely met with, the body-substance being transparent, the "shining bodies," of rounded or oval figure, can readily be seen, imbedded in the hyaline and homogeneous protoplasm, besides numerous vesicular spaces, lying, as described by Greeff, in the richly-granular intervening substance, the whole not unlike *Actinophrys Eichhornii*, but not so regular or compact. The vesicles vary in size, and their place in the protoplasmic substance is subject to constant change, such change being governed by the movements of the organism. In addition to the elements described, there are always present, in this species, rod-like bacteria scattered through the protoplasm in great numbers.

Greeff remarks that the body, in *Pelomyxa palustris*, consists of pure protoplasm, and is composed of two strata—an outer cortical one and an inner parenchyme. The former is hyaline and homogeneous; it is the chief seat of contractility, and hence in it the locomotive power resides. The whole inner parenchyme is of thinner consistence and is but passively moved; it is richly granular and filled with watery vacuoles, often so crowded that the substance appears reticulately interrupted. The two strata are not sharply marked off, but pass gradually into one another. In the so-composed body-mass there occur, then, three structures—(1) nuclei; (2) hyaline and homogeneous bodies of roundish, ovoid, or irregular figure, and glossy appearance (the *glanzkörper*); and (3) fine bacilliform bodies. These have for some time been regarded by most authors as symbiotic bacteria, and that this is their true nature has now been proved.

P. palustris is multi-nucleated. The nuclei are small and obscure; irregularly distributed between

the vacuoles of the endoplasm, most numerously in the central region; sparingly elsewhere (Pl. VII, figs. 1–3). In examples, say 1 mm. in diameter, there may, Greeff says, be some hundreds. This author describes them as delicately-walled bodies of globular, more rarely oval, figure, averaging 0·012 mm. in diameter. Their hyaline contents are pervaded more or less by dark granules; and their position, form, and appearance give in all respects the indubitable impression of cell-nuclei.

Reproduction takes place by fission, or, as has been more generally observed, by the formation of amœboid zoospores. The amœbulæ, after liberation, pass into a resting state, and ultimately develop a flagellum, or vibratile filament, passing thence into the adult phase.

Dimensions variable, mature individuals attaining 2 mm. diameter (Greeff); average diameter of a quiescent individual, exclusive of the pseudopodia, about 150 μ.

In the ooze of ponds and ditches, especially such as are partially shaded, in bogs, and amongst *Sphagnum* in stagnant water; not very frequent.

This organism is the largest of the amœboid rhizopods. To the naked eye it is often visible as a speck of semi-opaque matter—yellowish brown by transmitted light—of which the outline undergoes constant change. A pocket lens of moderate power will reveal it with certainty under favourable conditions.

In her admirable paper in the Linnean Society's 'Journal,' Mrs. Veley (*née* Gould) has given the results of some years' careful observations on the physical structure of *Pelomyxa palustris*. In confirmation of suggestions previously put forward by Prof. Bourne and Dr. Penard, she adduces definite proof of the nature of the rod-like structures. That they are true bacteria is shown (*a*) by their mobility and division, (*b*) by their reactions, and (*c*) by successful culture. They are referable to the genus *Cladothrix* Cohn

(= *Sphærotilus* Kützing, Mig.), and are recognized as a distinct species—*Cladothrix pelomyxæ* Veley.*

The conclusions arrived at by Mrs. Veley with regard to *Pelomyxa* are summarized in her paper as follows :—

"(1) The rods are symbiotic bacteria, which complete their development within the protoplasm of *Pelomyxa* and are then ejected, breaking down into free 'swarmers,' which are ingested by other *Pelomyxæ*, and recommence the cycle.

"(2) The refringent bodies are proteid in nature; they consist of some form of albumin, which is probably a waste product of the metabolism of *Pelomyxa*; they have a two-fold relation to the bacteria, supplying them with a point of attachment necessary for their development, and (probably) also with a source of nourishment.

"(3) The pseudopodia of *Pelomyxa* are not always blunt and lobose, but often exceedingly attenuated and acute, are often reticulate or anastomosing, and of a different character from any hitherto described for this animal. Classifications based on the lobose nature of the pseudopodia are hereby invalidated.

"(4) The division of *Pelomyxa* is of a simple character, in which the nuclei do not play an important part. The only other form of reproduction observed has been, in a single instance, the production of amœbæ, whereby the observations of Greeff and Korotneff are partly, and those of Penard entirely, confirmed.

"(5) Under certain circumstances a portion of one *Pelomyxa* may fuse with the protoplasm of a portion of a second *Pelomyxa*, the inference from this observation being that it may prove necessary to regard *Pelomyxa* as a plasmodium."†

The production of acute, sharply-pointed, pseudopodia (a phenomenon we have never observed), it ought to be stated, is not habitual with *Pelomyxa*, except under special conditions, "as when a portion is constricted off naturally, or the animal is getting rid of a

* 'Journ. Linnean Soc.,' Zool., vol. xxix, p. 386. † *Loc. cit.*, p. 393.

large solid or rigid body," when the contour becomes temporarily quite ragged, and whip-like pseudopodia of exceeding fineness are shot out with great suddenness and velocity, extending to a considerable length. "Pseudopodia of this kind," the author remarks, "are exceedingly attenuated and acute, and are, for a great part of their length from the tip inwards, perfectly hyaline, appearing to be actual prolongations of the hyaline border; they often, but by no means always, radiate outwards, and very frequently anastomose, the connecting bridge between two pseudopodia being sometimes hyaline, but more often consisting of fine strands of granular protoplasm."*

As bearing on the subject of classification, we are unable as yet to see that the production of these fine and occasionally anastomosing pseudopodia are of any special significance. They are evidently adventitious, depending upon conditions peculiar to the individual, and not characteristic of the species in the absence of such conditions. It does not appear that they perform any natural function. They are projected "with great suddenness and velocity," when some hard substance is being got rid of, and so soon as the producing cause is withdrawn, they are re-absorbed. In other words, their production is the result of a sudden rupture of the ectosarc, occasioned by the accidental circumstance of a foreign body having to be ejected at that spot. This removes them from the category of true pseudopodia, and marks an essential difference between them and the finely-attenuated and anastomosing pseudopodia which distinguish the Reticulosa.

2. **Pelomyxa villosa** Leidy.

(Plate VII, figs. 4–6.)

Amœba villosa (Wallich) Slack in Intell. Obs. III (1863), p. 430, ff. p. 433.

Amœba sabulosa Leidy in Proc. Acad. Nat. Sci. Phil. 1874, p. 87.

* *Loc. cit.*, p. 390.

Pelomyxa villosa Leidy Fresh. Rhiz. N. Amer. (1879), p. 73, t. v; Hitchcock Synops. Freshw. Rhiz. (1881), p. 8; Gruber in Zeits. f. wiss. Zool. XLI (1885), p. 189, t. xiii, ff. 1–4; Certes Cap. Horn. Zool. VI (1889), Prot. p. 20; Bourne in Q. J. Micr. Sci. XXXII, n.s. (1891), p. 362, etc.; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 48; Frenzel Mikr. Fauna Argent. I, Prot. 1 (1892), p. 21, t. iii, f. 18, and 4 (1897), p. 147, in Bibl. Zool. IV; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 56; Blochmann in Biol. Centralbl. XIV (1894), pp. 86, 115; ? Scourfield in Proc. Zool. Soc. 1897, p. 787; Penard in Rev. Suisse Zool. VII, no. 1 (1899), p. 16, t. i, ff. 7–19; Wilson in Amer. Nat. XXXIV (1900) p. 548, etc.; Issel in Atti Acc. Torino, XXXVI (1901), p. 68; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 310; Cash in Journ. Linn. Soc., Zool. XXIX (1904), p. 218.

Amœba laureolata Penard Faune Rhiz. Léman (1902), p. 131, ff.

In structure and general character closely resembling the preceding species, differing from it mainly in its somewhat smaller size, and in the possession of a caudal bulb, which is bordered with villi. Leidy describes the organism as nearly opaque, except when young, appearing, by transmitted light, brown or black, with a hyaline border, but by reflected light yellowish white, varied with other colours dependent on the contained food. The body is spheroid or oval, in the resting condition slightly compressed; but in active movement it is generally more or less ovoid, with the broad extremity in advance, movement being effected by broad wave-like expansions of the anterior ectoplasm. The villi covering the terminal bulb are closely compacted, filiform, straight, simple or ramose, with a tendency in some individuals to become short and papillary. Frequently at the posterior extremity a bundle of pseudopodal processes, digitate or conical, composed of clear ectoplasm, will form either in the vicinity of the villous bulb or at some short distance from it, or they may be developed, singly or otherwise, on various parts of the body-surface. They disappear during the animal's activity. The contractile vesicles

are small and inconspicuous, usually posterior; the nuclei as in the preceding species.

Dimensions variable; usually much smaller than *P. palustris*; active individuals 250 μ in longest diameter, and 100–130 μ in width anteriorly.

In the ooze of shaded ponds, with the preceding species; also in ditches and bogs.

The caudal bulb of *P. villosa*, though capable of modification, and even of temporary extinction in the active life of the animal, is nevertheless sufficiently distinctive, as, however obliterated in form, it always returns to the normal condition. In some attitudes, as when the body expands laterally, the villi become spread out along the margin, forming a kind of frill. This, however, is only a temporary phase.

Genus 5. **LITHAMŒBA** Ray Lankester, 1879.

Lithamœba Ray Lankester in Q. J. Micr. Sci. XIX, n.s. (1879), p. 484.

Body amœbiform, discoid, with a rounded or subelliptic outline, distinguished by the presence within the semitransparent endoplasm of numerous concretionary elements, varying in size, and reniform; pseudopodia lobular, hernia-like, never digitate; the nucleus large and conspicuous, punctated.

Whilst having a general resemblance to *Amœba*, this genus has a characteristic nucleus, and the peculiar concretions (on which the name is founded) further distinguish it.

1. **Lithamœba discus** Ray Lankester.

(Plate V, fig. 5.)

Lithamœba discus Ray Lankester in Q. J. Micr. Sci. XIX, n.s. (1879), p. 484, t. xxiii; and in Encycl. Brit. ed. 9, XIX (1885), p. 843, f. v.

Body discoid, distinguished by the vacuolation of its protoplasm, and the presence, within it, of reniform concretions; also by its large, block-like, tesselated nucleus, and the peculiar hernia-like pseudopodia, which appear to burst with a sudden action through a toughish cortical layer. Contractile vesicle central.

Dimensions: About 125 μ in diameter (*Ray Lankester*).

In ponds near Birmingham, discovered by Mr. Thomas Bolton.

In his description of *Lithamœba* (*loc. cit.*, 1879), Professor Lankester says that the pseudopodia differ from those of *Amœba*, being rounded and lobular, never digitate, resembling rather "the hernia-like extensions of the protoplasm exhibited in *Pelomyxa*." It is easy, he says, to recognize a distinct pellicle, or temporary cuticle, which is formed upon the surface of the protoplasm and bursts when a pseudopodium is formed. In fact it is the rupture of this pellicle which appears to be the approximate cause of the outflow of protoplasm as a pseudopodium. "Probably a still more delicate pellicle forms on the surface of the naked protoplasm, and, in the way just indicated, determines by its rupture the form and the direction of the 'flow' of protoplasm which is described as the protrusion of a pseudopodium."

Prof. Lankester discovered an excessively fine reticulate or vacuolar surface-structure. This differentiation of the protoplasm, he says, can be detected all round the margin of the disc-like body, in fact wherever the protoplasm is sufficiently free from concretions, or food-matter, to allow of proper illumination or inspection. The numerous concretions which may be seen imbedded in the endoplasm are minute, with a tendency towards a reniform outline. These bodies, he thinks, are only a larger form of the refringent granules which are present in great quantity in the protoplasm of the common large *Amœba*.

The nucleus is large, peculiar in shape ("block-like"), distinctly punctated or tesselated, and has a definite capsule. In the structure of this organ, and the delicate cuticle of its protoplasm, *Lithamœba* is considered by its author as "unlike any other form, whilst the combination of characters which it presents entitles it to a very distinct position among the amœboid Gymnomyxa."

The organism is apparently very rare. We have not met with it. The foregoing description is taken from Prof. Lankester's monograph.

Genus 6. **OURAMŒBA** Leidy, 1879.

Amœba (pars) Archer in Q. J. Micr. Sci. VI, n.s. (1866), p. 190.
Ouramœba Leidy Freshw. Rhiz. N. Amer. (1879), p. 66.

Body amœboid, with a granular endoplasm, a single contractile vesicle, and discoid nucleus. Pseudopodia digitate, arising from any part of the body-surface, usually anterior; the posterior extremity habitually furnished with one or more tufts of rigid, linear, non-contractile protoplasmic filaments, branching radially from points in the vicinity of the contractile vesicle.

The posterior filaments, which are the peculiarity of this genus, alone distinguish it from *Amœba*. These filaments are sometimes cast off, and by some authors have been held to be of no physiological significance.

1. **Ouramœba vorax** Leidy.

(Plate V, fig. 6.)

Amœba villosa (Wallich) Archer in Q. J. Micr. Sci. VI, n.s. (1866), p. 190; *op. cit.* X, n.s. (1870), p. 305; in Journ. Dublin Micr. Club, I, 2 (1867), p. 56; and *op. cit.* II, 1 (1872), p. 15.
Amœba villosa? Archer in Q. J. Micr. Sci. XIV, n.s. (1874), p. 212, and in Journ. Dublin Micr. Club, II, 3 (1875), p. 314.

Ouramœba vorax Leidy in Proc. Acad. Nat. Sci. Phil. 1874, p. 78; *op. cit.* 1875, p. 127; and Freshw. Rhiz. N. Amer. (1879), p. 67, t. ix, ff. 1–12; Maggi in Atti Soc. Ital. XIX (1876), p. 405; Parona in Boll. Scient. I, an. 2 (1880), p. 47; Hitchcock Synops. Freshw. Rhiz. (1881), p. 7; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 94.

Ouramœba lapsa Leidy in Proc. Acad. Nat. Sci. Phil. 1874, p. 78.

Ouramœba Archer in Q. J. Micr. Sci. XVI, n.s. (1876), p. 337, and in Journ. Dublin Micr. Club, III, 2 (1877), p. 128.

Ouramœba villosa Ray Lankester in Encycl. Brit. ed. 9, XIX (1885), p. 842.

The peculiar caudal appendage, consisting of, usually, from one to three tufts of straight, rigid filaments, emanating from a common stalk, is the characteristic feature of this organism, distinguishing it at once from the larger forms of *Amœba proteus*, and also from *A. villosa*. The appendage is dragged behind, in the animal's progress, and appears not to undergo any modification.

Dimensions: Length 140 μ and upwards; caudal filaments about 180 μ.

Ireland (*Archer*, 1866).

Mr. Archer was the first to record this organism as British. He exhibited it in 1866, at a meeting of the Dublin Microscopical Society, as a form of *Amœba villosa*, and subsequently, on the appearance of Professor Leidy's work, in which it was treated as generically distinct, he adhered to his conclusions and dissented from those of the Professor, on the ground that the posterior processes were (as he believed) capable of retraction. Leidy found that, except in the possession of this peculiar appendage, *Ouramœba* differed in no way from the larger specimens of *Amœba proteus*; though in some instances the posterior part of the body assumed "a mulberry-like appearance, which simulated a patch." Archer describes the prolongations as "forming a compact bundle, linear, often

as long as the ordinary length of the animal, about the middle often with a slight groove-like constriction, or narrowing, their thin ends terminating abruptly. Nine out of ten specimens in his gathering exhibited these appendages.

Professor Lankester (*loc. cit.*) abolishes Leidy's specific name, and unites this organism with *Amœba villosa*, under the title of *Ouramœba villosa*. In his *Amœba nobilis* (which may be a form of *Ouramœba* Leidy) Penard mentions the occurrence of similar caudal filaments, which he regards as parasitic ('Faunа Rhiz. du Bass. du Léman,' p. 66).

Leidy describes another form allied to *O. voraæ*, namely *O. botulicauda*, much smaller than *O. voraæ*, "colourless, transparent, with an irregularly-angular outline." The caudal appendages in this case consist of from two to nine "acutely-divergent, segmented filaments of variable length."

Family 2. Reticulosa.

Naked protoplasts belonging in part to the homogeneous and assumed non-nucleated Monera of Haeckel. Body sub-spherical or elongated; the pseudopodia branching out into exceedingly slender filaments, which anastomose, and form, in some species, a widely-spread net-work.

Synopsis of the Genera.

Body colourless, sub-spherical or oval, changing but slightly in contour; the pseudopodal filaments few and widely extending. 7. *Gymnophrys.*

Body during active movement much elongated, forming filamentous branching and anastomosing pseudopodia at various points, but mainly at the extremities. 8. *Biomyxa.*

Body extensile, its contour during activity very variable; the pseudopodia anastomosing and forming an extended net-work of fine protoplasmic threads.

9. *Penardia*.

Protoplasm hyaline, granular, containing, besides numerous small pulsating vacuoles, a mass of rounded or fusiform pale-bluish corpuscles, which travel simply up and down the delicate, widely-spreading pseudopodal filaments. Body in the resting state enclosed in a toughish cellulose cyst which is formed in the leaf-cells of *Sphagnum* and other sub-aquatic plants, and from which the organism escapes at maturity.

10. *Chlamydomyxa*.

Genus 7. **GYMNOPHRYS** Cienkowski, 1876.

Gymnophrys Cienkowski in Arch. f. Mikr. Anat. XII (1876), p. 31.

Body persistently sub-spherical or ovoid, changing little in general contour; the endoplasm colourless (containing sometimes a few greenish particles), and emitting at various points fine elongated anastomosing and widely-spreading pseudopodia, in which is a perceptible granular current. No nucleus visible.

The small sub-spherical or oval body, from which spring widely-extending, geniculate, and extremely attenuated pseudopodia (few in number and many times longer than the body-diameter), sufficiently separate this genus from *Biomyxa*, although it agrees with that genus in the character of the endoplasm. In *Biomyxa* the body is more elongated, and branched, and the pseudopodia form a closer network.

1. **Gymnophrys cometa** Cienkowski.

(Plate VIII, figs. 1 and 2.)

Gymnophrys cometa Cienkowski in Arch. f. mikr. Anat. XII (1876), p. 31, t. v, f. 25; Archer in Q. J. Micr. Sci. XVII, n.s. (1877), p. 348, t. xxi, f. 22; Lanessan Traité Zool., Prot. (1882), p. 34, f. 26; Griffiths and Henfrey

Micr. Dict. ed. 4 (1883), p. 367; Blochmann Mikr. Thierw. Süsswass. (1886), p. 11, t. i, f. 13, and ed. 2 (1895), p. 14, t. i, f. 9; Rolleston Forms Anim. Life, ed. 2 (1888), p. 920; Penard in Rev. Suisse Zool. IX (1901), p. 238, and Faune Rhiz. Léman (1902), p. 546, ff.; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 311, t. xxviii, f. 3; Cash in Journ. Linn. Soc., Zool. XXIX (1904), p. 222.

Protoplasm finely granular, colourless, or presenting a faint greenish tinge from the presence of chlorophyllous particles; the body persistently sub-spherical or irregularly elliptic, with no apparent nucleus or contractile vesicle; subject to few changes superficially, but emitting at from two or more points fine, mostly elongated and diverging—never crowded—pseudopodia, which branch out into fine filaments and anastomose. The pseudopodia are of irregular thickness, swollen at intervals, and granular throughout, the granules exhibiting a circulatory movement. Pseudopodia are occasionally formed, which do not attain the average length, and possess considerable mobility. The longer and finer ones are very inactive, and sometimes remain stationary for long periods; they may be straight, bent at a sharp angle, branched, or elongated and curved, sometimes measuring in length six to ten times the diameter of the body.

Dimensions: Average diameter of body 35–40 μ, sometimes 80 μ or more; length of the pseudopodia anything up to 400 μ, or even longer.

In *Sphagnum*, Lindow and Dunham, Cheshire; Carnarvonshire, N. Wales. Near Brigg, Lincolnshire (*West*).

Cienkowski describes *Gymnophrys cometa* as a moneron, whose anastomosing pseudopodia, possessing a distinct granular current, are confined to a few points only of the body-surface—not regularly distributed over it. Except that the pseudopodia appear somewhat more numerous, in adult individuals, the Cheshire examples agree well with this author's description. They vary in size. Not infrequently small

forms are met with which seem to emit pseudopodia only at opposite poles of the oval body, as Cienkowski, and likewise Penard, figure it. The filaments are not, in any case, numerous. The body of the animal is always pale; the pseudopodal threads are extremely fine and transparent, divergent and widely spreading, their branches anastomosing. No developmental process has yet been detected in *Gymnophrys*. Two individuals which were under observation at one time came into actual contact, but they did not incorporate, nor was there any blending of their pseudopodia.

Genus 8. **BIOMYXA** Leidy, 1875.

Biomyxa Leidy in Proc. Acad. Nat. Sci. Phil. 1875, p. 124.

Body consisting of finely-granular protoplasm, semi-fluid and colourless; initial form sub-spherical; the body capable of much elongation, and branching out into a network of fine anastomosing filaments, which are generally massed at the extremities, but may also emanate from different points of the surface.

From *Gymnophrys* this genus is distinguished by the habit of the body to elongate, and of the finer pseudopodia to become massed at the extremities, whilst from *Penardia* the pale colourless endoplasm clearly marks it off. From the latter it is further separated by general habit (being purely a chlorophyl feeder) and by its more dilatory movements.

1. **Biomyxa vagans** Leidy.

(Plate VIII, figs. 3 and 4.)

Biomyxa vagans Leidy in Proc. Acad. Nat. Sci. Phil. 1875, p. 125, and Freshw. Rhiz. N. Amer. (1879), p. 281, t. xlvii, ff. 5–12; t. xlviii, ff. 8, 12 (?); Corrado in Boll. Scient. I, an. 2 (1880), p. 47; Griffiths & Henfrey Micr. Dict. ed. 4 (1883), p. 98; Gruber in Nova Acta Acad. Caes. Leop. XLVI (1884), p. 503, t. ix, ff. 27–31; Bolton in Midl. Nat. IX (1886), p. 174; Whitelegge in

Proc. Linn. Soc. N. S. Wales, (2) I (1886), p. 504; Rolleston Forms Anim. Life, ed. 2 (1888), p. 920; Mœbius in Abh. K. Akad. Wiss. Berlin, 1888 (1889), 2, p. 23, tt. iv–v, ff. 46–51; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 55, t. ii, f. 12; Penard Faune Rhiz. Léman (1902), p. 548, ff.; Rhumbler in Arch. f. Protisten-Kunde, III (1903), p. 187, f. 2.

Body when contracted roundish or roughly ovoid; at other times mobile, throwing out branching and inosculating pseudopodia which form ultimately an intricate net-work, "often," to quote Leidy's description, "expanding into perforated patches." Protoplasmic substance pale, finely granular, rarely containing chlorophyllous matter; but numerous minute vesicles and oil-like molecules are usually present, the former occurring near the margin of the body and along the pseudopodal extensions. The nuclear structure is undetermined. A circulation of minute granules is perceptible along the filamentous pseudopodia.

Dimensions extremely variable.

In swampy ground, amongst *Sphagnum*; also in tufts of moss on moist rocks. Dunham, Cheshire; Isle of Man.

The pale colourless protoplasm and its finely and uniformly granular structure are distinctive of this organism, separating it at once from *Leptophrys* H. and L., of which no British examples, so far as we know, have been found. The Isle of Man examples of *Biomyxa*, which occurred in tufts of *Barbula* growing on rocks near the coast, at Perwick Bay, agreed most closely with Leidy's description and figures. A study of Leidy's figures on Plates xlvii and xlviii of 'Freshw. Rhiz. N. Amer.,' leads to a suspicion that he may have included *Gymnophrys* with this genus.

Genus 9. **PENARDIA** Cash, 1904.

Penardia Cash in Journ. Linn. Soc., Zool. XXIX (1904), p. 223.

Body when at rest roundish or ovoid; at other times expanded, and during progression exceedingly mobile; the endoplasm a deep chlorophyllous green, with a pale marginal band, varying in width, of more or less clear granular ectoplasm; the pseudopodal filaments slender, branching and anastomosing, ultimately forming a widely-spreading network, colourless. Nucleus inconspicuous; contractile vesicles (one or more) small, usually occurring in the semi-transparent ectoplasm.

The bright green colour of the endoplasm, and its peculiar structure, distinguish *Penardia* from other Gymnomyxa with which it might be confounded. The predatory habits of the animal are also characteristic.

This genus has been named in honour of Dr. Eugène Penard, of Geneva, whose works on the Rhizopoda are so well known, and whose exploration of the Swiss lakes has brought to light many previously unknown species.

1. **Penardia mutabilis** Cash.
(Plate IX.)

Penardia mutabilis Cash in Journ. Linn. Soc., Zool. XXIX (1904), p. 223, t. xxvi, ff. 1, 2.

Body when at rest roughly ovoid, with almost inert branching and anastomosing pseudopodia projecting from the surface at various points; the central mass opaque (semi-opaque near the periphery), without definite structure; at other times compressed and exceedingly mobile, the entire body expanding, elongating and contracting incessantly, and throwing out from different parts of the surface a widely-extending network of fine anastomosing pseudopodia which are used for the capture of prey. In this mobile condition the body becomes nearly transparent, and the endoplasm is seen to contain a mass, with a well-defined general outline, of bright or yellowish-green corpuscles, oval in shape and closely compacted, but without apparent nucleus. Vacuoles appear in the ectoplasm, generally near the base of the branching pseudopodia.

Dimensions: Diameter when at rest 90–100 μ; fully extended (including pseudopodia) 300–400 μ.

In swampy ground, adjoining Copped Hall Lodge Road, Epping Forest, June, 1901.

The animal was not abundant in the locality mentioned, but all the individuals met with had the above-mentioned features sufficiently well marked. Rotifers seemed to form its staple food. When one of these came in contact with the pseudopodal filaments it was firmly held and escape became impossible. Other pseudopodia closed around it; then streams of protoplasm set in from opposite directions, drawing the prey gradually closer to the surface of the body, till it became completely enveloped. During this process the body of *Penardia* became congested; the pseudopodia not in use were withdrawn, or reduced in size; and in a comparatively short space of time the prey was completely engulphed, the animal then remaining for an indefinite period inert.

Genus 10. **CHLAMYDOMYXA** Archer, 1875.

Chlamydomyxa Archer in Q. J. Micr. Sci. XV, n.s. (1875), p. 107.

Body naked, or, during the encisted or resting phase, "enclosed in a multi-laminated cellulose envelope, whence, through an apparently lacerated aperture, the non-nucleated granule-bearing protoplasmic contents emerge, irregularly giving off at the same time, in an arborescent manner, gradually tapering ramifications, and emitting numerous extremely slender hyaline ramifying threads (filamentary tracks) occasionally coalescing and forming a more or less complex 'labyrinth,' along which proceed from the central mass, as from a reservoir, numerous little, therein pre-existent non-nucleated globular bodies, which, during progression, assume a fusiform figure" (Archer, *l.c.*).

The habit of secreting a cellulose envelope, and passing the encisted state within the tissues of *Sphagnum*, is unique amongst the Rhizopoda, being characteristic of *Chlamydomyxa labyrinthuloides* Arch. *C. montana* Ray Lank. appears to be a non-parasitic species, and differs from the former in other important particulars.

1. **Chlamydomyxa labyrinthuloides** Archer.
(Plate XIV, fig. 1.)

Chlamydomyxa labyrinthuloides Archer in Q. J. Micr. Sci. XV, n.s. (1875), p. 107, tt. vi, vii; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 282, f. 8; Bütschli in Bronn's Thier-Reichs, I, 1 (1880), t. i, f. 9; Geddes in Q. J. Micr. Sci. XXII, n.s. (1882), p. 30, t. v; Ray Lankester in Encycl. Brit. ed. 9, XIX (1885), p. 843, f. vi, 2; Delage & Hérouard Zool. concr. I (1896), p. 82, f. 76; Hieronymus in Hedwigia, XXXVII (1898), p. 1, tt. i–ii, ff. 1–14 (? 15–22), and ff. 1–10 in text; Jenkinson in Q. J. Micr. Sci. XLII, n.s. (1899), p. 89, ff. a–e (*non* f).

This organism is, in an early stage of its existence, endo-parasitic, living within the tissues of aquatic plants, "the general mass, with or without sub-division, becoming periodically and repeatedly encisted; its enveloping coat hyaline, of a pale yellowish colour when viewed at the margin (or through its greater thickness), remaining thus long dormant." In that condition the bodies which during active life become fusiform, are globular, and they are mixed with yellowish green (sometimes bright red) pigment-granules; and, during expansion and the branching out of the protoplasmic body, the latter is seen to contain numerous rounded pulsating vacuoles. The extended pseudopodia ("filamentary tracks") are extremely slender, and hyaline; the so-called "spindles" bluish in colour, apparently homogeneous, and plastic, their progression along the filaments a slow gradual gliding. They are when in motion about $\frac{1}{3000}$ or $\frac{1}{4000}$ of an inch in length and about half that in breadth.

Dimensions of cist variable.

Parasitic on *Sphagnum* in bogs, County Westmeath (*W. Archer*).

Mr. Archer, who discovered this singular organism, and whose description of it we have condensed, says that the test, or coat, which encloses the protoplasmic body, is composed of several layers of the same kind of material, has an irregular outline, and is often very thick, according to the number of lamina. It is tough, and requires strong pressure of the covering-glass to burst it. The outer figure is variable in form, and often presents neck-like extensions of greater or less width, terminating in a lacerated orifice.

The presence of *Chlamydomyxa* in quantity, in the bogs of Connemara, was revealed by the reddish colour of the *Sphagnum*, which held the organism in the encisted condition. It is this colour which first attracts attention under the microscope. When encisted and completely dormant the cellulose envelope appears densely filled with the granular substance.

Mr. Archer found that in spite of the seemingly tough consistence of the envelope, it was capable of being burst by the organic substance which escaped and entered upon a period of amœboid activity. The protoplasmic body is without any hyaline border, and the hyaline branching filaments extend and ramify in an extraordinary manner. They are flexible, but while not seen to alter much in position, they grow in length and in number. *Pari passu* with their appearance there occur at various distances upon their surface the minute fusiform bodies ("spindles") previously referred to, which glide along very slowly.

Professor Geddes (*loc. cit.*) discusses the affinities of *Chlamydomyxa* and its systematic position. The semi-amœboid character of the organism in its resting state, and its exalted amœboid activity when motile, might, he says, tempt one rather to refer it to the Thalamophora. "Its cellulose wall, its red, green, and

yellow colouring matter, make it seem rather referable to the algæ, a view greatly strengthened by the existence of a Protococcus stage, . . . it would thus take a place among the lower algæ which the Myxomycetes do among the lower fungi." On the whole this author is "inclined to regard it as a degenerate form from the Palmellaceous algæ, but one sufficiently aberrant to take place alone, and form the type of a new order, the Chlamydomyxida." In any case, he considers it almost an ideal "Protist" which cannot be distinctly appropriated by either botanist or zoologist without a certain violence to the other."

Hieronymus* held that, if not actually belonging to the vegetable kingdom, *C. labyrinthuloides* was at any rate on the border-land, but nearest to that kingdom by reason of its chromatophores and cellular membrane. He admitted that, in some of its phases, it was certainly holozoötic, but on a review of all the evidence he came to the conclusion that it must occupy the lowest place among the yellow-brown algæ. His theory of this organism and its relationship was, however, ridiculed by Professor Lankester in a foot-note to the translation cited.

Family 3. Vampyrellida.

Naked rhizopods with amœboid movements; pseudopodia variable, sometimes radiate, simulating those of the Heliozoa. Nuclei mostly obscure; in some species unknown.

Synopsis of the Genera.

Plasma-body soft, granular, reddish, variable in outline, sometimes spherical or sub-spherical, with radiating pseudopodia. 11. *Vampyrella.*

* In 'Hedwigia,' vol. xxxvii (1898). See Jenkinson's "Abstract and Review" of this memoir in 'Quart. Journ. Micr. Science,' vol. xlii, n.s. (1899).

Body discoid, granular and reddish as in the preceding genus, variable in outline, usually oval, consisting of a mobile endoplasm which contains numerous vacuoles and is surrounded by a zone of colourless transparent ectoplasm. 12. *Hyalodiscus.*

Nucleated organisms frequently with an external mucous envelope, which adapts itself to the varying movements of the individual. Endoplasm sometimes much vacuolated; pseudopodia sharply pointed. 13. *Nuclearia.*

Organism distinguished by the possession of a chlorophyl corpuscle, which apparently represents the nucleus. Forming colonies by tetraschistic division. 14. *Archerina.*

Genus 11. **VAMPYRELLA** Cienkowski, 1865.

Amœba (pars) Fresenius in Abh. Senckenb. nat. Ges. II (1856), p. 253.

Vampyrella Cienkowski in Arch. f. mikr. Anat. I (1865), p. 205.

Body actinophrys-like or polymorphous, plastic, and capable of much variation; possessing an obscure nucleus or scattered nuclear substance, but destitute, in most cases, of a contractile vesicle. Protoplasm granular, permeated with a reddish pigment, and containing food-corpuscles and oil-like globules of variable size. In certain species fusion of two or more amœboid individuals takes place immediately upon contact, forming plasmodia.

The reddish colour present in nearly all the *Vampyrellæ* distinguishes this genus from other naked Gymnomyxa. All are chlorophyl feeders. They differ from the *Amœbæ* in the character of their pseudopodia, which, as a rule, are very fine and very mobile. The habit of forming plasmodia by fusion of individuals is particularly noticeable in one species of *Vampyrella*.

1. **Vampyrella lateritia** (Fresen.) Leidy.

(Plate X; Pl. XI, figs. 1–3.)

Amœba lateritia Fresenius in Abh. Senckenb. nat. Ges. II (1856), p. 218, t. x, ff. 13–19.

Vampyrella spirogyræ Cienkowski in Jahrb. wiss. Bot. III (1863), p. 428, and in Arch. f. mikr. Anat. I (1865), p. 218, tt. xii–xiii, ff. 44–56; Hæckel in Jen. Zeits. f. Med. u. Nat. IV (1868), p. 133, and Biol. Stud. XII (1870), p. 72; Hertwig and Lesser in Arch. f. mikr. Anat. X (1874), Suppl. p. 61, t. ii, f. 2; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 419, f. 11; Archer in Q. J. Micr. Sci. XVII, n.s. (1877), p. 347; Maggi in Rend. R. Ist. Lomb. (2) X (1877), p. 367, and in Boll. Scient. III, an. 10 (1888), p. 105; Bütschli in Bronn's Thier-Reichs, I, 6 (1880), t. xii, f. 11; Klein in Bot. Zeit. XL (1882), col. 214, and in Bot. Centralbl. XI (1882), p. 256; Lanessan Traité Zool., Prot. (1882), p. 28, ff. 10–13; Ray Lankester in Encycl. Brit. ed. 9, XIX (1885), p. 839, f. ii, 5–7; Zopf Pilzthiere oder Schleimp. (1885), p. 104, f. 10, i–iii, f. 11, iii, iv, f. 37 e–g; Dangeard in Ann. Sci. Nat., Bot. (7) VI (1886), pp. 252, 254; Binet Vie psych. in Psych. expér. (1888, 1891), p. 235, and (Engl. transl.) Psych. Life (1889), p. 114; Penard in Arch. Sci. Phys. XXII (1889), p. 523, and in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 119, t. i, ff. 1–16.

Vampyrella lateritia Leidy Freshw. Rhiz. N. Amer. (1879), p. 253, t. xlv, ff. 10–16; S[eward] in Amer. Journ. Micr. V (1880), p. 105, ff.; Hitchcock Synops. Freshw. Rhiz. (1881), p. 46; Blochmann Mikr. Thierw. Süsswass. (1886), p. 19, t. ii, f. 42, and ed. 2 (1895), p. 22, t. ii, f. 35; Whitelegge in Proc. Linn. Soc. N. S. Wales, (2) I (1886), p. 503; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 95; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 53, t. ii, ff. 22, 23; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 57; Crawley in Amer. Nat. XXXIV (1900), p. 255, ff.; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 333, t. xxix, ff. 29–31, and *op. cit.* XXIX (1903), pp. 109, 112.

Body ordinarily spherical, but susceptible of variation; in the active state appearing as a reddish actinophrys-like form, displaying numerous straight

elongated and filamentous pseudopodia, and intermixed with them a variable number of shorter and stouter capitate processes which elongate and contract incessantly. Wave-like or lobate expansions of clear ectoplasm, and sometimes also digitate processes, are frequently emitted from the periphery. No nucleus of the normal type has been detected in this species, but Zopf demonstrated the presence of scattered grains of nuclear substance. The animal is stated by most observers to be destitute of a contractile vacuole, but in some states (probably young) one, if not more, is undoubtedly present, though obscured more or less by the brick-red contents of the plasma-body. The chlorophyl of filamentous algæ seems to form the sole food of *V. lateritia*, but the animal does not confine itself to any particular species. It glides through the water with a motion similar to, but more rapid than, that of *Actinophrys*, and on coming in contact with an alga-filament will often travel along it and sometimes break it at the joints, or pierce the individual cell, in order to extract the chlorophyl.

Dimensions variable, averaging 30–40 μ in diameter.

In shallow bog-pools, amongst wet *Sphagnum*, and occasionally in ponds and ditches amongst Confervæ. Not infrequent in Cheshire, associated with *Acanthocistis*, etc.; and in Epping Forest. Near Brigg, Lincolnshire; Harris, Outer Hebrides (*G. S. West*).

The habits of this species make it one of the most interesting of the tribe. The Rhizopoda, as a rule, feed on such things as fall in their way. They are gleaners merely. *Vampyrella lateritia*, on the contrary, seems to hunt for its food, and has, in a very humble degree, a power of selection. Once found, a filament of *Spirogyra*, or other allied alga, is taken possession of by the *Vampyrella*, and not given up until the animal's needs are satisfied, when it usually passes into an inert or resting state in which it will remain for an indefinite period. Its method of attacking a filament

differs, probably, according to the hardness of the integument. Our own observations prove that the organism will first anchor itself to an alga—usually to the terminal cell—by means of its longer and more mobile pseudopodia, which have a remarkable power of concentration. They will gather in a bundle on that side of the body, where, for the purpose, they are most required. By an exertion of force, difficult to understand in so tiny a creature, the filament is snapped at a joint, and access to the interior of a cell is thus gained, the contents being rapidly absorbed by the introduction of two or more digitate, pseudopodal processes.

The method is illustrated on Plate X. Figures 1 to 4 were drawn from an example found in the marsh at Dunham, Cheshire. The *Vampyrella*, in this case, attached itself to the terminal cell of a filament, broke it off and emptied it. Afterwards joint after joint were severed, and finally the joints were left, as represented, lying almost at right angles. A curious fact observed was that alternate joints only of the Conferva were cleared of their chlorophyl.

The method above described would appear, from the descriptions of other authors, to be a very unusual one. Cienkowski, in 'Archiv für Mikr. Anat.' (1865), describes the organism as penetrating the cell-wall of *Spirogyra* laterally—making a perforation in the integument, and through that extracting the chlorophyl. More recent writers have made the same observation. West ('Journ. Linn. Soc.,' Zool., vol. xxviii, p. 333) found several of these animals, in a collection from Lincolnshire, feeding on the cell-contents of a species of *Mougeotia*. He says: "The animal attached itself firmly to the lateral margin of one of the cells of the filament, and in a very short time the long, delicate pseudopodia were retracted. At the same time the clear, outer, protoplasmic zone was continually putting forth and retracting shorter and stouter pseudopodia. That portion of the animal which originally attached

itself to the cell very soon had perforated it, a portion of the animal protoplasm passing into the cell and causing a violent dancing movement of the granules of the vegetable protoplasm. Whilst this was happening the chromatophore of the *Mougeotia*-cell was observed to be disintegrating at a point immediately opposite the place of attachment of the animal. I watched this destruction go on for about two hours; it was accompanied by much violent movement on the part of the small granules of the protoplasm, but during that time only a portion of the chromatophore and surrounding protoplasm of the vegetable cell had been absorbed by the *Vampyrella*."

The exertion of force by an individual *Vampyrella* explains its action, in this case as in the other. This was pointed out by Penard so long ago as 1889, in a paper communicated to the Physical and Natural History Society of Geneva.* "The *Vampyrella* is said to pierce a hole in the cell of *Spirogyra*," the author remarks, "and to introduce into it a pseudopodium, the business of which is to search the contents of the cell. The phenomenon, which I have observed repeatedly, may be described thus: The *Vampyrella* attaches itself to a cell of *Spirogyra*, retracts its pseudopodia, except a few by which it adheres to the alga, and then moulds itself to the cell upon a portion of its surface, and becomes motionless. For a moment nothing takes place. Then we see the attached zone rise up into an arch in the interior, the margins remaining firmly attached and formed into a ring; the arch gradually rises, and suddenly the wall of the alga bursts, the cell-juice of the *Spirogyra* passes in a violent stream into the *Vampyrella*; the greyish plasma of the cell passes, in its turn, more slowly, with the green chromatophore, which is seen to glide in a mass; the cell is completely emptied; the *Vampyrella* emits pseudopodia, becomes detached, and moves away, leaving a very visible rupture in the empty cell. It then goes

* 'Archives des Sciences Physiques et Naturelles,' tome xxii, p. 523.

to the next cell, or even to a third, and having emptied these in the same manner, and become greatly enlarged, it encists itself." The nutrition of *Vampyrella*, the author remarks, is effected by a true phenomenon of suction, the entire body of the animal assisting in the operation. This phenomenon is very different from what the earlier observers described as a simple piercing of the cell-wall of the alga, and certainly is more in accord with the physical conditions.

The presence of the "pin-head" rays, and their action, during the activity of the *Vampyrella*, very soon attract notice. They are remarkable, as Leidy points out, for the quickness with which they are successively projected and withdrawn. At times they are only projected in the slightest degree beyond the outline of the body, and rarely to a greater length than 125 μ. Sometimes an individual, when first noticed, will exhibit only ordinary rays, projecting from some portion, or the whole surface, of the body, and after a while the pin-like rays, in variable number, will issue from some portion or the whole surface. Their action is so rapid as to keep the surface of the body, at times, in a state of agitation. Penard describes their appearance as being due to the fact that, especially when the animal is progressing, very small hyaline spheres run constantly over these rays, seeming to be thrown out by the animal and to fall again immediately to the very point from which they were expelled.

The method of reproduction most frequently observed in *V. lateritia* is by the formation of amœboid or actinophrys-like spores, after encistment. Prof. Lankester* says that cists are formed which enclose a single amœboid individual. The cist often acquires a second or third inner cist-membrane by the shrinking of the protoplasmic body after the first encistment and the subsequent formation of a new membrane. The encisted protoplasm sometimes merely divides into four parts, each of which creeps out of the cist as an *Actino-*

* Article "Protozoa," 'Encycl. Britannica,' ed. 9.

phrys-like *Amœba*. In other instances it forms a dense spore, the product of which is not known.

Encistment usually takes place after the taking of food. Penard (*l. c.*) observed this in examples which he studied. After it has emptied several *Spirogyra* cells, *V. lateritia*, he says, loses its brick-red colour, which is at the utmost visible here and there in spots in the greenish mass with which the body is stuffed. "Later on it will divide within its cist into several embryos, which will pierce a hole, and issue, one after the other, already clothed in their fine red colour."

We have not ourselves witnessed the phenomenon exactly as described, but in an example from Dunham the occurrence was noted of the emission of an amœboid spore. This took place when the animal was still attached to a conferva filament, after gorging itself with the cell-contents. The "spore" presented itself as a particle of greyish protoplasm, finely granular, and furnished with a contractile vacuole, and a small sphericle corpuscle which may have represented a nucleus. Its movements were comparatively rapid. The pseudopodia were at first acuminate, straight, and sharply pointed (Pl. X, fig. 5), but ultimately, after complete severance from the parent body, they became digitate and blunt. The ultimate development of this young *Vampyrella* was not traced, but it retained the amœboid form during the short time that it was under observation (Pl. X, figs. 6, 7).

V. lateritia is sometimes found presenting characters varying from those described, and which make it difficult of identification. Bütschli, in Bronn's 'Thier-Reichs,' represents its form as elongated and slug-like (Pl. XI, fig. 3), without the capitate rays, and destitute also of elongated pseudopodal filaments, but furnished, in place of these, with a profusion of short, radiating, tapering, and sometimes branching filaments, which clothe the entire body-surface. An Essex example (Pl. XI, fig. 1) represents the animal in this condition, but with a spherical body which is clearly the normal

form. All Essex specimens examined were smaller and less active than those met with in Cheshire; they had less of the characteristic red colour; and, in some, one or more pulsating vesicles were distinctly visible.

2. **Vampyrella vorax** Cienkowski.
(Plate XI, figs. 4–6.)

Vampyrella vorax Cienkowski in Arch f. mikr. Anat. I (1865), p. 223, tt. xiii–xiv, ff. 64–73, and *op. cit.* XII, (1876), p. 24, tt. iv–v, ff. 14–17; Hæckel in Jen. Zeits. f. Med. u. Nat. IV (1868), p. 133, and Biol. Stud. XII (1870), p. 72; Maggi in Rend. R. Ist. Lomb. (2) X (1877), pp. 364, 371; Klein in Bot. Zeit. XL (1882), col. 213, and in Bot. Centralbl. XI (1882) pp. 195, 255, t. ii; Blochmann Mikr. Thierw. Süsswass. (1886), p. 19, and ed. 2 (1895), p. 22, t. ii, f. 37; Dangeard in Ann. Sci. Nat., Bot. (7) IV (1886), pp. 249, 253, t. ix, ff. 14–18, and in Le Botan. VII, 3 (1900), p. 131, t. iv; Penard in Mem. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 120, t. i, ff. 17–20.

? *Vampyrella variabilis* Klein in Bot. Centralbl. VIII (1881), p. 321; *op. cit.* X (1882), p. 347; *op. cit.* XI (1882), pp. 189, 257, t. i; in Bot. Zeit. XL (1882), col. 214, t. iva, ff. 1–11; and in Biol. Centralbl. II (1882) p. 137, f.; Zopf Pilzthiere oder Schleimp. (1885), p. 105, f. 8, ii–vi; Dangeard in Ann. Sci. Nat., Bot. (7) IV (1886), pp. 252, 254.

Leptophrys vorax Zopf Pilzthiere oder Schleimp. (1885), p. 109, ff. 3, ii; 9, v; 11, vii; Delage & Hérouard Zool. concr. I (1896), p. 70, f. 55.

Plasma-body minute, multiform, usually more or less elongated, and broader at one extremity than at the other; changing constantly; the extremities produced into long tapering flexible pseudopodia, which sometimes branch at the base, and are formed of the same granular substance as the body. Other pseudopodia of the same type are emitted laterally or tangentially from different parts of the surface, appearing and disappearing with the movements of the organism. The margins of the remarkably fluid, granular reddish plasma-body are usually ill-defined, that is to say, not

indicated by any definite marginal line. Progression is mostly lateral, the broad side in advance emitting a mass of radiating pseudopodal filaments, some long and fine, others short and faintly capitate. No nucleus or contractile vacuole is visible. Reproduction is effected by encistment and the formation of swarm-spores.

Dimensions variable; average length, exclusive of pseudopodia, 40–70 μ; breadth 20–30 μ.

In ponds, amongst Confervæ and floating *Hypna*; Cheshire.

The habits of this species are not less singular than those of the preceding, from which, however, it differs very materially in form. The plasma-body is remarkably fluid. Two individuals, coming together, fuse like drops of water, and, this having taken place, the compound organism pursues a career in all respects like that of the previously separate individuals, the only apparent difference being its increased size.

This condition of *V. vorax* was found by Klein to follow encistment. The contents of the cist break up into "swarm spores," which attain their freedom, conjugate, and later form either double or multiple individuals (plasmodia). An example is figured (Plate XI, fig. 4) of two individuals, each containing a diatom incepted as food, having united in the manner described. As many as four are said to have been observed to fuse in this manner.

The movements of the animal are habitually lateral. A considerable number of tentacle-like filaments are thrown out in the direction of progression.

3. **Vampyrella flabellata** Cash.

(Plate XI, figs. 7–12.)

Vampyrella flabellata Cash in Journ. Linn. Soc., Zool. XXIX (1904), p. 224, t. xxvi, ff. 5, 6.

In structure resembling the preceding species, and about the same in size, but differing in habit; most

frequently appearing as an ovoid or double-convex elongated body, narrowed at the extremities, each extremity being furnished with a bundle of short, capitate, pseudopodal filaments, with other simple ones intermixed. One or more filamentous pseudopodia are usually to be seen projecting from the body-surface, but these are inconstant, appearing and disappearing at various points. Not infrequently the entire body becomes remarkably elongated, when it appears as though a long, tapering pseudopodium had been thrust out posteriorly (Pl. XI, figs. 8, 11) whilst the anterior plasma expands and takes a fan-shaped outline, clothed with pseudopodal filaments of varying length, the shorter ones mostly capitate. The posterior prolongation is induced by the adhesion of the plasma-body, at a point on the convex surface, to some foreign object (or to the glass slip over which it is moving) whilst the forward movement is continued, the body posteriorly thus becoming more and more attenuated, smooth throughout, and terminating in a sharp point. The food of the animal consists of minute diatoms. Like the preceding species it is destitute of contractile vacuole, and apparently also (so far as has been observed) of nucleus. Its life-history is unknown, though it may be presumed to be analogous to that of *V. voraæ*, with which it is most nearly allied.

Dimensions : Length of the ovoid body 60–70 μ; average breadth 20–30 μ. When elongated, measuring from the convex face to the posterior extremity, 110 μ, or more.

In water from a sluggish stream near Barking, Essex, amongst Confervæ, etc., May, 1901.

V. flabellata may be distinguished from *V. voraæ* by its paler colour, and also by its peculiar movements. It is very active, and its pseudopodal changes are unceasing. The examples which furnished the above description (and which were kept under observation for a considerable time) had little or none of the red

tint characteristic of other *Vampyrellæ*; but this may have been a temporary or accidental condition.

4. **Vampyrella gomphonematis** Hæckel.

(Pl. XI, figs. 13–15.)

Vampyrella gomphonematis Hæckel Biol. Stud. XII (1870), p. 163, t. vi, ff. 1–4, and in Jen. Zeits. f. Med. u. Nat. VI (1871), p. 23, t. ii, ff. 1–4; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 421, f. 12; Bütschli in Bronn's Thier-Reichs, I. 6 (1880), t. xii, f. 13; Klein in Bot. Zeit. XL (1882), col. 212, and in Bot. Centralbl. XI (1882), p. 255; Lanessan Traité Zool., Prot. (1882), p. 28, ff. 14–16; Zopf Pilzthiere oder Schleimp. (1885), p. 108, f. 40; Dangeard in Ann. Sci. Nat., Bot. (7) IV (1886), pp. 253, 254; Maggi in Boll. Scient. III, an. 10 (1888), p. 115.

Body, in its initial form, round or ovoid, with a reddish tinge, minute, very inactive; without apparent nucleus or contractile vacuole; its surface covered with a mass of fine hair-like irregular pseudopodal filaments, giving the organism a villous appearance. The animal undergoes considerable mutation when feeding on diatoms (gomphonemas and naviculas) of which it appropriates the chlorophyllous contents.

Dimensions: About 20–25 μ in diameter.

In still pools, amongst Confervæ; Cheshire.

V. gomphonematis is the smallest of the *Vampyrellæ*, and liable to be passed by without recognition, unless engaged feeding on the stipitate *Gomphonemæ*, as figured by Hæckel, when it will expand and envelop an entire group of frustules with its soft plasma-body. In this process the pseudopodia undergo considerable modification (Pl. XI, fig. 15). We have never observed the animal in this condition. Ordinarily it is found feeding on *Naviculæ*, a single frustule of which it will envelop, and, after extracting the contents, reject the hard test, proceeding to others, and treating them similarly.

Genus 12. **HYALODISCUS** Hertwig & Lesser, 1874.

Amiba (pars) Dujardin Infus. (1841), p. 235.
Hyalodiscus Hertwig & Lesser in Arch. f. mikr. Anat. X (1874), Suppl. p. 49.
Placopus F. E. Schulze in Arch. f. mikr. Anat. XI (1875), p. 348.
Vampyrella (pars) Klein in Bot. Centralbl. VIII (1881), p. 321.

Body discoid, of indefinite outline, surrounded by a band of clear ectoplasm of varying width, with a reddish, frequently much vacuolated granular endoplasm in which may be detected, under favourable conditions, an inconspicuous nucleus. Endoplasm similar in appearance to that of *Vampyrella*, sometimes projected into conical or filamentous processes.

The band of transparent ectoplasm, completely enveloping the body, is distinctive of this genus, and separates it from the allied *Vampyrellæ*.

1. **Hyalodiscus rubicundus** Hertwig & Lesser.

(Plate XIII, figs. 2–11.)

Hyalodiscus rubicundus Hertwig & Lesser in Arch. f. mikr. Anat. X (1874), Suppl. p. 49, t. ii, f. 5; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 267, f. 2; Archer in Q. J. Micr. Sci. XVII, n.s. (1877), p. 342, t. xxi, f. 16; Maggi in Rend. R. Ist. Lomb. (2) X (1877), p. 321; in Atti Soc. Ital. XXI (1878), pp. 313, 317; and in Boll. Scient. I, an. 2 (1880), p. 34; Hitchcock Synops. Freshw. Rhiz. (1881), p. 10; Lanessan Traité Zool., Prot. (1882), p. 48; Blochmann Mikr. Thierw. Süsswass. (1886), p. 10, t. i, f. 5; Sacchi in Boll. Scient. III, an. 10 (1888) p. 43, and *loc. cit.* an. 11 (1889), p. 68; Levander in Acta Soc. Fauna Fenn. XII (1894), no. 2, p. 11, and in Zool. Anzeig. XVII (1894), p. 209; Penard Faune Rhiz. Léman (1902), p. 159, ff.

Plakopus ruber F. E. Schulze in Arch. f. mikr. Anat. XI (1875), p. 348, t. xix, ff. 9–16; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 270, f. 4; Archer in Q. J. Micr. Sci. XVII, n.s. (1877), p. 349, t. xxi, f. 23; Lanessan Traité Zool., Prot. (1882), p. 49.

Vampyrella pedata Klein in Bot. Centralbl. VIII (1881), p. 321; *op. cit.* X (1882), p. 347; *op. cit.* XI (1882), pp. 204, 259, t. iv, ff. 1–19; in Bot. Zeit. XL (1882), col. 216, t. iva, ff. 27–32; and in Biol. Centralbl. II (1882), p. 139; Zopf Pilzthiere oder Schleimp. (1885), p. 106, f. 38, v–viii; Berthold Stud. Protopl.-mech. (1886), pp. 95, 104, t. ii, f. 1; Dangeard in Ann. Sci. Nat., Bot. (7) IV (1886), pp. 253, 255; Blochmann Mikr. Thierw. Süsswass. ed. 2 (1895), p. 22, t. ii, f. 40; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 334.

Endoplasm finely granular, reddish, generally occupying the central part of the discoid body, with a highly-pellucid and broadish band of ectoplasm extending all round, and changing form, within certain limits, during the activity of the animal, sometimes projecting short conical or acute pseudopod-like prominences, but almost invariably, when progress is not intercepted, preserving the discoid character. Projections of the granular endoplasm, more or less numerous, extend (mostly in fine lines) from the ill-defined frontal margin of the endoplasm outwards to the periphery of the ectoplasm, but not beyond, with shorter and more variable ones intermixed. Posterior margin of the endoplasm more sharply defined, and destitute of the projections last mentioned.

Dimensions: Length of hyaline disc 50–80 μ; breadth about 30 μ.

In ponds amongst surface-vegetation; Cheshire. In the lakes at Capel Curig and in Lynn-y-cwm-ffynon, North Wales (*G. S. West*).

This species is evidently closely related to *Vampyrella vorax*, but we have thought it right to preserve Hertwig and Lesser's generic name, on account of the manifest peculiarities of the organism which those authors were the first to point out. It appears, under a moderate power of the microscope (to quote their description), as an oval body, reddish-brown in colour, gliding slowly along. Under higher magnification this

reddish body is seen to form only the central region, which is surrounded by a colourless and hyaline border. Then the appearance of the organism is that of a colourless disc, with a granular, coloured mass occupying ordinarily a central position, but sometimes posterior. The margin is homogeneous and structureless, and is seen with difficulty, while the central coloured region is more or less sharply defined. The authors observed in the endoplasm a variable number of greenish-brown bodies which they regarded as more or less accumulated food-substances, of vegetable origin, becoming more reddish with the progress of digestion, and mingled with them were numerous vacuoles, which at times were difficult to be made out owing to the opacity of the body-substance.

This organism sometimes exhibits a degree of mobility, occasioning variations of form and appearance, which renders it difficult of identification. Its progress being intercepted by any object, the disc-like body will double back upon itself, and the animal will set off in some other direction. This seems to be the habit represented by Schulze in his figures and description of the organism which he named *Plakopus ruber*, but which there is little reason to doubt was the *Hyalodiscus rubicundus* of Hertwig and Lesser.

According to Schulze one or more nuclei are present, not readily observable in the ordinary state, but under reagents becoming evident. A comparatively large nucleolus is surrounded by a clear round border, with its outer limits only seldom sharply marked. It is remarked also (referring to *Plakopus ruber*) that a variable number of different-sized pellucid vacuoles is scattered through the body-mass. This is characteristic of our Cheshire examples. The outer hyaline stratum is, under a high magnification, faintly granulated.

The mode of reproduction of this organism has not been sufficiently studied. In all probability it is analogous to that of *Vampyrella*.

Genus 13. **NUCLEARIA** Cienkowski, 1865.

Nuclearia Cienkowski in Arch. f. mikr. Anat. I (1865), p. 225.
Heterophrys Archer in Q. J. micr. Sci. X, n.s. (1870), p. 110.
Heliophrys (pars) Greeff in Arch. f. Mikr. Anat. XI (1875), p. 28.

Single- or multiple-nucleated amœboid organisms, with or without a mucous envelope, which, when present, is defined by a granulated surface and an irregular outer margin, often villous in appearance, from the presence of innumerable delicate radiating processes or spicules imbedded in the mucus. The body, in its initial form sub-spherical, emitting a variable number of sharply-pointed radiating or irregularly-disposed pseudopodia; during activity varying in contour from sub-spherical to quadrate or roughly triangular, the angles not infrequently acute and produced into elongated tapering sharply-pointed straight or branched pseudopodia; the mucous envelope when present adapting itself to the mutations of the animal.

This genus is allied to *Vampyrella*. Certain species (*e.g. N. delicatula*) when resting, simulate the Heliozoa, as does *V. lateritia* in some of its phases; but their habit of assuming amœboid forms, and their usually straight and sharply-pointed pseudopodia, distinguish the *Nucleariæ*.

1. **Nuclearia delicatula** Cienkowski.

(Plate XII.)

Nuclearia delicatula Cienkowski in Arch. f. mikr. Anat. I (1865), p. 225, t. xiv, ff. 74–78; Bütschli in Bronn's Thier-Reichs, I, 6 (1880), t. xiii, f. 1; Maggi in Rend. R. Ist. Lomb. (2) XIII (1880), pp. 729, 732; Blochmann Mikr. Thierw. Süsswass. (1886), p. 20, t. ii, f. 43, and ed. 2 (1895), p. 21, t. ii, f. 32; Cattaneo in Boll. Scient. III, an. 10 (1888), p. 94; Sacchi in Boll. Scient. III, an. 10 (1888), p. 43; Artari in Zool. Anzeig. XII (1889), p. 409, ff. 1–12; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 52; Delage and Hérouard Zool. concr. I (1896), p. 163, f. 244; Frenzel Mikr. Fauna Argent. I, Prot. 4 (1897),

p. 149, in Bibl. Zool. IV; Calkins Prot. (1901), p. 56, and in Amer. Nat. XXXV (1901), p. 647, f. 1.

? *Heterophrys myriapoda* Archer in Q. J. Micr. Sci. X, n.s. (1870), p. 100, t. xvii, f. 4;

Heterophrys varians F. E. Schulze in Arch. f. mikr. Anat. X (1874), p. 386, t. xxvi, ff. 2–5.

Heliophrys variabilis Greeff in Arch. f. mikr. Anat. XI (1875), p. 28, t. ii, ff. 20–23; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 385, ff. 1, 2.

Heliophrys varians G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 336.

Body in the initial (resting) state heliozoon-like, generally with a more or less hyaline margin, and invested with a gelatinous envelope of variable thickness, which is fimbriated on the outer edge, and surrounded by numerous short radiating acineta-like processes. The pseudopodia usually rigid, tapering from an expanded base, and formed of hyaline ectoplasm; sometimes branched; in certain (presumably young) states the pseudopodia are straight or whip-like, slender, and mobile, and the animal is destitute of any external covering. During activity the movements of the adult are rapid; the body becomes elongated, or roughly triangular, the outer envelope adapts itself to the forms assumed, and the pseudopodia —often grouped at the angles—become more elongated, extend far beyond the margin of the envelope, and exhibit a tendency to branch, always preserving their rigidity. The body in such individuals is often crowded with bright-green food-particles, with some oil-like globules; younger ones are freer of coloured matter and more transparent; and a contractile vacuole and one or more nuclei are generally visible.

Dimensions: Diameter of body (without pseudopodia) 40 μ, or over.

Ponds in Cheshire, 1890. In ditches near Brigg, Lincolnshire (*G. S. West*). In the ooze of ponds and in marshes, Ireland (*W. Archer*).

Considerable ambiguity has always hung around

the genera *Nuclearia* and *Heterophrys*. Archer (*loc. cit.*) described *Heterophrys myriapoda*, upon which he founded the genus, as a Heliozoon. His figures accord so closely with undoubted examples of *H. varians* in the heliozoon-like phase, that one is almost forced to the conclusion that *Heterophrys myriapoda* Archer, *H. varians* Schulze, and *Heliophrys variabilis* Greeff, are separate phases of a single species, which must be regarded as identical with *Nuclearia delicatula*.

The habit of what may be assumed to have been a young state of the species under notice (Pl. XII, figs. 7, 8), was extremely puzzling. The pseudopodia were mobile, sometimes straight, clustered at various angles of the body, or scattered, curved, and whip-like, changing their position repeatedly and apparently performing the function of tentacles. The movements of these young, comparatively-transparent individuals, reminded one of *Vampyrella lateritia* in its most active state, but in other respects they differed widely from that species.

In one form of the species (Pl. XII, figs. 1, 2) there was an absence of the external envelope, but the movements of the organism were normal. In the heliozoon phase the spherical body gave off a large number of short radiating pseudopodia, composed of clear ectoplasm, with three or four more-conspicuous ones at various points. Only when in active movement could the affinities of this organism be arrived at.

If further investigation should establish the identity of *Heterophrys myriapoda* Arch., with *Nuclearia delicatula* Cienk., Archer's genus *Heterophrys* should, it seems to us, be dropped. West, however ('Journ. Linn. Soc.,' Zool., vol. xxviii, p. 337), describes under the name of *Heterophrys radiata*, a small, dark-grey heliozoon, possessing an outer colourless gelatinous coat, almost as thick as the diameter of the body, with a finely-fimbriated outer surface, and numerous long and delicate pseudopodia. It has no affinity with *Nuclearia*.

2. **Nuclearia conspicua** G. S. West.

(Plate XIII, fig. 1.)

Nuclearia conspicua G. S. West in Journ. Linn. Soc., Zool. XXIX (1903), pp. 109, 111, t. xiii, ff. 16–19.

Protoplasmic body sub-globose or angularly rounded; protoplasm undifferentiated, granulose, containing numerous large vacuoles, with a single large spherical nucleus which exhibits a punctate appearance; pseudopodia fairly numerous, stout, rigid, generally with one or two branches which are a little divergent and attenuated to fine points.

Dimensions: Diameter of body 83–120 μ; length of pseudopodia 17–54 μ.

In boggy pools, Lewis, Outer Hebrides (*G. S. West*).

This rhizopod, Prof. G. S. West (whose description we have quoted), records having found in considerable profusion amongst numerous desmids and other algæ in small pools. The animals, he says, "are of much larger size than *N. delicatula* Cienk., or *N. simplex* Cienk., and the protoplasm is much more vacuolated. There is a single nucleus present in each individual, but no contractile vacuoles were observed. The pseudopodia are protruded irregularly from the surface of the body-protoplasm, often in small clusters. They are broad at the base, generally straight and much attenuated, and almost always branched. Except for their perfectly smooth exterior and absence of granules, they are very like those present in the genus *Vampyrella*." The species is a voracious feeder.

Genus 14. **ARCHERINA** Ray Lankester, 1885.

Archerina Ray Lankester in Q. J. Micr. Sci. XXV, n.s. (1885), p. 61.

Body spherical, minute, furnished with long, delicate, radiating pseudopodal filaments, one or more large vacuoles, and a single bifid chlorophyl corpuscle, which

apparently represents the nucleus. Occurring singly and in tetraschistic colonies. The chlorophyl corpuscle, which takes the place of a true nucleus, is unique, and sufficiently characteristic of this genus.

1. **Archerina Boltoni** Ray Lankester.

(Plate XIV, figs. 2–6.)

Archerina Boltoni Ray Lankester in Q. J. Micr. Sci. XXV, n.s. (1885), p. 61, t. vii, and in Encycl. Brit. ed. 9, XIX (1885), p. 840, f. ii, 8–11.

Body of each individual sphere about one-thousandth of an inch in diameter, consisting of a sharply-defined mass of refringent protoplasm from the surface of which radiate stiff filaments, some of which are four times as long as the diameter of the sphere and taper from the base towards the extremity. The base of each filament, according to Prof. Lankester (whose description we quote), is relatively broad, and appears to join, without penetrating, the surface of the sphere. No membrane or pellicle can be detected on the surface. Within the body is usually one large spherical vacuole; sometimes there are more, varying in size.

Dimensions: Individual spheres, 1–2000″ (*Lankester*).

Ponds near Birmingham, Mr. Thomas Bolton (after whom the species was named), the generic name being established in honour of Mr. William Archer.

This rhizopod was found in great abundance in pond-water, associated with desmids and other minute chlorophyl-bearing algæ. Its spherical corpuscles may at first, Professor Lankester says, be mistaken for those of such microscopic plants, but a little attention is sufficient to enable one to detect around many of the bright green spheres a halo of radiant protoplasm frequently in the form of very long and stiff filaments. Once recognized it is not difficult to distinguish *Archerina*, in its various phases of growth and multiplication, from its associates.

In describing the life-history and affinities of this organism the author says :* "*Archerina* is clearly one of the non-nucleate Gymnomyxa (Homogenea or Monera), and is, in so far as regards the various forms which its protoplasm may assume, not far removed from Cienkowski's *Vampyrella*. It is, however, definitely characterized and distinguished by its nucleus-like chlorophyl-corpuscle. No other Protozoon is known the form of which is thus dominated by a chlorophyl-corpuscle, nor is there any form with a chlorophyl-bearing nucleus which might be compared with it. In regard to nutrition it clearly gives evidence of both plant-like assimilation of carbon through the agency of its chlorophyl-corpuscles, and of the usual ingestive voracity of the naked Protozoa."

Elsewhere Prof. Lankester remarks : † "*Archerina* exhibits an amœba phase in which the protoplasm is thrown into long stiff filaments surrounding a spherical central mass, about one two-thousandth of an inch in diameter (actinophryd form). A large vacuole (non-contractile) is present, or two or three small ones. No nucleus can be detected by a careful use of reagents in this or other phases. The protoplasm has been seen to ingest solid food-particles (bacteria) and to assume a lobose form. The most striking feature of *Archerina* is the possession of chlorophyl corpuscles. In the actinophryd form two oval green-coloured bodies are seen. As the protoplasm increases by nutrition, the chlorophyl corpuscles multiply by quaternary division and form groups of four or of four sets of four symmetrically arranged. The division of the chlorophyl corpuscles is not necessarily followed by that of the protoplasm, and accordingly specimens are found with many chlorophyl corpuscles embedded in the large growth of protoplasm ; the growth may increase to a considerable size, numbering some hundreds of chlorophyl corpuscles, and a proportionate development of protoplasm. Such a growth is not a

* 'Q. J. Micr. Sci.,' *l. c.* † 'Encycl. Brit.,' *l. c.*

plasmodium, that is to say, is not formed by fusion of independent amœba forms, but is due to continuous growth. When nutrition fails, the individual chlorophyl corpuscles separate, each carrying with it an investment of protoplasm, and then each such amœba form forms a cyst around itself, which is covered with short spines. The cysts are not known to give rise to spines, but appear to be merely hypnocysts. The domination of the protoplasm by the chlorophyl corpuscles is very remarkable and unlike anything known in any other organism. Possibly the chlorophyl corpuscles are to be regarded as nuclei, since it is known that there are distinct points of affinity between the dense protoplasm of ordinary nuclei and the similarly dense protoplasm of normal chlorophyl corpuscles."

Order II. CONCHULINA.

Family 1. Arcellida.

Test simple, transparent, homogeneous, or composed of numerous and variously-formed chitinoid plates, or opaque from encrustation with sand-grains or other extraneous material; monothalmous; pseudopodia mostly digitate, rarely lobular; nucleus single or multiple; contractile vesicles one or several.

Synopsis of the Genera.

Test discoid, membranous; in dorsal view circular, laterally hemispherical or depressed; mouth central. 15. *Arcella.*

Test discoid, circular, flexible in the young state, the outer lamina extremely thin; oral aperture irregular and rarely distinguishable. 16. *Pseudochlamys.*

Test discoid, with a circular or broadly oval, sometimes irregular outline, obtusely rounded and thickened posteriorly; the oral aperture excentric, round, oval, or lobate. 17. *Centropyxis.*

Test a plain membranous structure encrusted in most cases with a variable amount of extraneous matter (sand-grains, diatom frustules, etc.); in others semi-transparent, chitinoid, with few sand-grains; multiform, mostly round in transverse or dorsal view; rarely compressed. 18. *Difflugia.*

Test similar to the preceding, more frequently compressed, with a constricted neck, and an internal transverse loop, or bridge, dividing the neck at the point of constriction. 19. *Pontigulasia.*

Test membranous, transparent, smooth; protoplasm granular; pseudopodia one or more, central, digitate, mobile, with a terminal apiculus; and usually two others (one on each side) issuing laterally, which are thin, rigid, and tapering. 20. *Difflugiella.*

Test unsymmetrical, usually forming a semi-spiral, with vermiform or irregular surface-markings, semi-transparent or opaque; pseudopodia digitate. 21. *Lecquereusia.*

Test transparent, chitinoid (rarely siliceous) symmetrical, compressed in transverse section, and constructed of minute circular, oval, or angular plates. 22. *Nebela.*

Test homogeneous, transparent, plain or pitted with circular, polygonal, or irregular depressions, compressed transversely. 23. *Hyalosphenia.*

Test chitinous, transparent or semi-opaque, with a faint irregularly-tesselated surfacing; compressed transversely; the crown covered with a variable number of angular sand-grains, or spined; the mouth convex. 24. *Heleopera.*

Test hyaline, compressed or sub-orbicular, composed of rectangular plates disposed with more or less regularity, transversely or in oblique series. 25. *Quadrula.*

Test homogeneous, thin, transparent, flexible; pseudopodia lobate or digitate. 26. *Cochliopodium.*

Test homogeneous, transparent, unsymmetrical; nucleus single; pseudopodium single, broadly lobate or cordate. 27. *Leptochlamys.*

Test sub-orbicular or hemispherical, chitinoid, with sand-grains or other extraneous matter adhering, the pseudopodia not distinctly digitate, often elongated and branched; more or less pointed. 28. *Phryganella*.

Genus 15. **ARCELLA** Ehrenberg, 1832.

Arcella (pars) Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1830 (1832), p. 40, and Infus. (1838), p. 132.
Arcellina Carter in Ann. Nat. Hist. (2) XVIII (1856), p. 247.
Difflugia (pars) Wallich in Ann. Nat. Hist. (3) XIII (1864), p. 245.

Test membranous, composed of transparent chitinoid material, turning brown with age, and densely punctated. Form variable; in dorsal or ventral aspect circular, with a central aperture; in lateral view varying from plano-convex to hemispherical, the mouth turned inwards and appearing as an inverted funnel. Externally the test is plain or (in certain varieties) variously ornamented, having the dome moulded into angular facets, pitted, or furnished with acute prominences springing from an upturned border, such prominences occasionally developing into spines. The protoplasmic body is centrally situated within the test, and attached to its internal margin, at various points, by threads of ectoplasm. Pseudopodia few, digitate, blunt, simple or branched; nuclei (usually two) situated on opposite sides of the body; contractile vacuoles (four or more) small, near the periphery.

Reproduction in this genus is most commonly effected by the formation of spores and by "budding," the latter being regarded as an intermediate process between simple fission and the complete breaking up of the parent body into spores. Nine or more globular processes have been observed (by Bütschli amongst others) surrounding the mouth; these get "pinched off," and, after passing a short existence as amœbulæ, escape, develop tests of the same pattern as the parent,

and finally assume its character and habits. These are not infrequently met with, fully developed, but distinguished from older individuals by their delicate texture and transparency.

1. **Arcella vulgaris** Ehrenberg.

(Plate XV, figs. 1–3 and 13–15, and figs. 17 and 18 in text.)

Arcella vulgaris Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1830 (1832), p. 40, t. i, f. vi; *op. cit.* 1831 (1832), p. 90; *op. cit.* 1871 (1872), p. 234; Infus. (1838), p. 133, t. ix, f. v; in Ber. K. Akad. Wiss. Berlin, 1845, p. 307; *op. cit.*, 1853, pp. 255, 266; and in Monatsb. K. Akad. Wiss. Berlin, 1869, p. 260; Blainville Man. d'Actinol. (1834), p. 623; Dujardin Infus. (1841), p. 247, t. ii, ff. 3–5; Pritchard Hist. Infus. (1842), p. 169; new ed. (1852), p. 211; and ed. 4 (1861), p. 555, t. xxi, ff. 7–9; Schmarda Kleine Beitr. Naturges. Infus. (1846), p. 30; in Denks. K. Akad. Wiss. Wien, VII (1854), 2, pp. 20, 25; and Zool. (1871), p. 163, f. 55; Siebold Anat. Wirb. Thiere (1848), p. 20, and (Engl. transl.) Anat. Invert. (1854), p. 30; Perty in Mitth. naturf. Ges. Bern, 1849, pp. 124, 163, and Kenntn. kleinst. Lebensf. (1852), p. 186, t. ix, ff. 1–3; Bailey in Smithson. Contrib. II (1851), art. 8, *passim*; Cole in Proc. Essex Inst. I (1853), p. 45; Claparède in Arch. f. Anat. 1854, pp. 401, 419; Owen Anat. Invert. Anim. ed. 2 (1855), p. 26; Carter in Ann. Nat. Hist. (2) XVIII (1856), pp. 128, 132, 221, t. vii, f. 79, and *op. cit.* (3) XIII (1864), p. 30, t. ii, f. 14; Lieberkuhn in Arch. f. Anat. 1856, p. 33; Claparède & Lachmann Études Inf. et Rhiz. 2 (1859), p. 444; Gosse Ev. Micr. (1859), p. 462; Carpenter Foram. (1862, *Ray Soc.*), t. i, f. 19; Carus Handb. Zool. II, Prot. (1863), p. 591; Archer in Q. J. Micr. Sci. VI, n.s. (1866), pp. 185, 186, and in Q. J. Micr. Sci. XVII, n.s. (1877), p. 79; Schoch Mikr. Thiere, I (1868), p. 14, t. i, f. 21; Engelmann in Arch. f. ges. Physiol. II (1869), p. 318, and in Arch. Néerl. IV (1869), pp. 424, 438, t. vii, ff. 4, 5; Parfitt in Trans. Devon. Assoc. III (1869), p. 67; Hertwig & Lesser in Arch. f. mikr. Anat. X (1874), Suppl. p. 96; Leidy in Proc. Acad. Nat. Sci. Phil. 1874, p. 14; *op. cit.* 1876, p. 55; *op. cit.* 1879, p. 162; and Freshw. Rhiz. N. Amer. (1879), p. 170, tt. xxvii, xxviii, ff. 1-7; Bütschli in Arch. f. mikr. Anat. XI (1875), p. 459, t. xxv, and in Bronn's Thier-

Reichs, I, 1 (1880), t. ii, f. 9; Buck in Zeits. f. wiss. Zool. XXX (1878), pp. 4, 18, t. i, ff. c, h-m; Cattaneo in Atti Soc. Ital. XXI (1878), p. 331, t. vi; in Boll. Scient. I, an. 1 (1879), p. 57; and *op. cit.* III, an. 10 (1888), p. 91; Maggi in Atti Soc. Ital. XXI (1878), p. 314, etc.; Lanessan in Rev. Internat. Sci. VI (1880), p. 9, and Traité Zool., Prot. (1882), p. 53, f. 43; Parona in Boll. Scient. I, an. 2 (1880), pp. 24, 47, 48; Hitchcock Synops. Freshw. Rhiz. (1881), p. 25; Taránek in Sitz.-ber. K. Böhm. Ges. Wiss. 1881 (1882), p. 225; Vejdovsky Thier. Org. Brunn. Prag (1882), p. 45; Griffiths & Henfrey Micr. Dict. ed. 4 (1883), p. 70, t. xxx, f. 14 *a*; Phillips in Trans. Herts N. H. Soc. II (1883), p. 121; Gruber in Zeits. f. wiss. Zool. XL (1884), t. viii, f. 3, and in Zacharias Tier-welt Süsswass. I (1891), p. 139, f. 16, no. 6; Ray Lankester in Encycl. Brit. ed. 9, XIX (1885), p. 842, f. iv, 7; Lenderfeld in Proc. Linn. Soc. N. S. Wales, X (1885), p. 724; Blochmann Mikr. Thierw. Süsswass. (1886), p. 12, t. i, f. 16, and ed. 2 (1895), p. 15, t. i, f. 12; Whitelegge in Proc. Linn. Soc. N. S. Wales, (2) I (1886), p. 501; Fielde in Proc. Acad. Nat. Sci. Phil. 1887, p. 122; Harvey in Amer. Nat. XXII (1888), p. 73; Sacchi in Boll. Scient. III, an. 10 (1888), p. 47, and an. 11 (1889), p. 68; Verworn Psychophys. Prot.-Stud. (1889), p. 164, t. iv, f. 14; Zacharias in Biol. Centralb. IX (1889), p. 58, etc.; Cuneo in. Boll. Scient. III, an. 12 (1890), p. 42; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 151, t. v, ff. 56-66; in Rev. Suisse Zool. VII, 1 (1899), pp. 106, 107; *op. cit.* IX (1901), p. 237; and Faune Rhiz. Léman (1902), p. 398, ff.; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 95; Voeltzkow in Zool. Anzeig. XIV (1891), p. 225; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 51; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 57; Jelliffe in Amer. M. Micr. Journ. XIV (1893), p. 289; Schewiakoff in Mém. Acad. Impér. Pétersb. (7) XLI (1893), no. 8, p. 6; Shipley Zool. Invert. (1893), p. 11, f. 4; Levander in Acta Soc. Fauna Fenn. XII (1894), no. 2, p. 12, and in Zool. Anzeig. XVII (1894), p. 209; Longi in Atti Soc. Ligust. V (1894), p. 17, and *op. cit.* VI (1895), p. 70; Delage & Hérouard Zool. concr. I (1896), ff. 119-121, 124-126; Frenzel Mikr. Fauna Argent. I, Prot. 4 (1897), p. 148, in Bibl. Zool. IV; Daday Mikr. Süsswass. Ceylon (1898), pp. 5, 9; Hertwig in Festsch. C. von Kupffer (1899), p. 367, and Lehrb. Zool. ed. 2 (1901), p. 168; Calkins Prot. (1901), p. 218, f. 119;

G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 314; *op. cit.* XIX (1903), p. 109; and in Ann. Scott. Nat. Hist. 1905, pp. 89, 91; Dangeard in Compt. Rend. 1903, p. 769, and in Le Botan. IX, 1 (1903), p. 25; Pearl & Dunbar in Biometrica, II (1903), p. 321, f. 2 R.

Arcella viridis Perty in Mitth. naturf. Ges. Bern, 1849, pp. 160, 167, and Kenntn. kleinst. Lebensf. (1852), p. 186; Maggi in Atti Soc. Ital. XXI (1878), p. 314, etc.

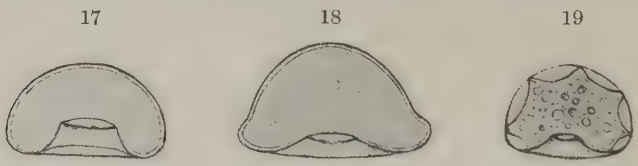
Arcella hemisphærica Perty in Kenntn. kleinst. Lebensf. (1852), p. 186, t. ix, f. 5; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 153, t. v, ff. 93-5, and Faune Rhiz. Léman (1902), p. 400, ff.

Arcellina vulgaris Carter in Ann. Nat. Hist. (2) XVIII (1856), p. 247, t. vii, f. 79.

Arcella patens Claparède & Lachmann Études Inf. et Rhiz. 2 (1859), p. 446, t. xxii, f. 7; Carter in Ann. Nat. Hist. (3) XIII (1864), p. 31, t. ii, f. 15.

Difflugia arcella Wallich in Ann. Nat. Hist. (3) XIII (1864), p. 245, t. xvi, ff. 34-38.

Test in dorsal or ventral aspect discoid, circular, with a central orifice, of which the margin is usually plain, but in some examples faintly crenulated; with a



Figs. 17 and 18.—*Arcella vulgaris*; common forms of test (side view), × 250.

Fig. 19.—*A. vulgaris*, var. *gibbosa*; ordinary small pond form (side view), × 300.

more or less distinctly but finely punctated surface. The mouth is concentric with the outer periphery of the test. In lateral view the outline is nearly or quite hemispherical, with convex borders; the height of the crown one half the breadth of the test—the dome evenly convex, and smooth, except in the varieties referred to. The protoplasm is colourless except for the presence of chlorophyl particles incepted as food; not completely filling the cavity, but forming attachments by means of divergent threads; the pseudopodia

not frequently extended beyond the outer margin of the test. Contractile vesicles, numbering four or more, situated near the outer margin of the endoplasm.

Dimensions: Diameter of test variable, averaging 70 μ or more; the mouth 12–20 μ.

Common and universally distributed, most frequent in the ooze and amongst surface vegetation in ponds.

The colour of the test varies from a clear hyaline or pale yellowish tint (in the young state) to a deep brown. The membrane is thin and pliable, becoming brittle with age. Conjugation has been observed to take place, accompanied by fusion of the protoplasm, but this is not of frequent occurrence. "Budding" is more common.

Var. **angulosa** (Perty) Leidy. (Plate XV, figs. 12 and 16.)

Arcella angulosa Perty Kenntn. kleinst. Lebensf. (1852), p. 186; Maggi in Atti Soc. Ital. XXI (1878), pp. 314, 315.
Arcella vulgaris var. *angulosa* Leidy Freshw. Rhiz. N. Amer. (1879), t. xviii, ff. 8–13.
Arcella costata (Ehrenb.) Penard in Rev. Suisse Zool. IX (1901), p. 237, and Faune Rhiz. Léman (1902), p. 401, ff.

Test smaller than in the type, faceted, forming a five- to eight-sided figure, with obtuse angles; the angles rising obliquely from the broad base to the narrower depressed summit. Mouth central; protoplasm, nucleus, and contractile vesicles as in the type.

Dimensions: Diameter of test averaging 30–40 μ.

Occurring occasionally in marshy places, amongst *Sphagnum*, and in ponds.

Var. **gibbosa** (Penard) G. S. West. (Plate XV, figs. 11 and 17; and fig. 19 in text.)

Arcella gibbosa Penard in Mém Soc. Phys. Genève, XXXI, no. 2 (1890), p. 155, t. v, ff. 96-99; t. vi, f. 1.
Arcella vulgaris var. *gibbosa* G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 314, and *op. cit.* XXIX (1903), p. 109.

Test gibbous, varying structurally from the type, and from var. *angulosa,* in having the surface pitted with circular depressions, which occur in regular series, are of uniform dimensions, and appear in transverse view as small concavities producing a broken outline. Protoplasm, nuclei, and contractile vesicles as in the type.

Dimensions: Average diameter of pond-form 45–50 μ; sometimes much larger. At Park Bridge, Lancashire, an individual (Fig. 15) was found measuring about 100 μ.

In ponds, amongst submerged vegetation in many parts of the country; also in marshy places amongst *Sphagnum.*

This variety is exceedingly handsome, especially in the young state, when the test has a yellowish tint, and is quite transparent. Its dimensions vary under different conditions; possibly there are two varieties with the same kind of pitted test—one, the smaller and much more plentiful, measuring not more than 40 μ or 45 μ; the other, represented by the Park Bridge example (Pl. XV, fig. 15), about twice the size, and with a much larger number of depressions. West records examples from Yorkshire of which the test, in some cases, was as much as 240 μ in diameter. Penard figures examples from the Jura with the orifice of the test (laterally viewed) directed downwards, instead of —as it occurs normally in the *Arcellæ*—upwards, facing the dome. These measured 80–90 μ in diameter; the dome, 50–60 μ in height.

2. **Arcella discoides** Ehrenberg.

(Plate XV, figs. 4–6, and fig. 20 in text.)

Arcella discoidea Ehrenberg in Ber. K. Akad. Wiss. Berlin, 1843, p. 139.

Arcella discoides Ehrenberg in Abth. K. Akad. Wiss. Berlin, 1871 (1872), p. 259, t. iii, f. 1; Leidy Freshw. Rhiz. N. Amer. (1879), p. 173, t. xxviii, ff. 14–38, and in Proc. Acad. Nat. Sci. Phil. 1879, p. 162; Corrado in Boll.

Scient. I, an. 2 (1880), p. 47; Hitchcock Synops. Freshw. Rhiz. (1881), p. 26; Whitelegge in Proc. Linn. Soc. N. S. Wales, (2) I (1886), p. 501; Fielde in Proc. Acad. Nat. Sci. Phil. 1887, p. 122; Harvey in Amer. Nat. XXII (1888), p. 73; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 153, t. v, ff. 70–74; in Rev. Suisse Zool. VII, 1 (1899), pp. 104, 107; and Faune Rhiz. Léman (1902), p. 402, ff.; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 95; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 51; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 57; Levander in Acta Soc. Fauna Fenn. XII (1894), no. 2, p. 13; Daday Micr. Süsswass. Ceylon (1898), pp. 5, 9; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 314; *op. cit.* XXIX (1903), p. 109; and in Ann. Scott. Nat. Hist. 1905, pp. 89, 92.

Arcella vulgaris var. *discoides* Issel in Atti Acc. Torino, XXXVI (1901), p. 64.

Arcella peristicta Ehrenberg Microgeol. (1854), p. 331; and in Abth. K. Acad. Wiss. Berlin, 1871 (1872), p. 260, t. iii, ff. 11, 13.

Arcella discoides (Ehrenb.) ? Leidy in Proc. Acad. Nat. Sci. Phil. 1876, p. 56.

Test discoid, circular in dorsal or ventral view, expanded, less convexly rounded at the basal angles than *A. vulgaris*, and of much greater breadth; also more transparent, the surface smooth, faintly punctated; the mouth central. In lateral view plano-convex, the breadth from the base to the apex of the dome measuring only about a quarter or third of the diameter; the crown convex, sloping evenly down to the expanded and but slightly rounded basal border. Protoplasm, etc., as in the allied species.

Fig. 20. *Arcella discoides*; ordinary pond-form (face view). × 200.

Dimensions: Diameter variable, averaging about 150 μ.

Frequent in ponds and marshes; less common than *A. vulgaris*.

Arcella discoides, though Leidy thought it might probably be only a variety of *A. vulgaris*, is readily distinguished by its greater delicacy and transparency, and by its much shallower and more widely-expanded test. Individuals sometimes occur whose tests are either immature, or ill-developed, or have sustained some injury (Pl. XV, fig. 6). These are almost invariably young forms.

Penard, in 'Mem. Soc. de Phys. et d'Hist. Nat. de Genève,' 1890, records, under the name of *A. polypora*, a form with the mouth distinctly everted, but in other respects, except as regards size, hardly differing from *A. discoides*. It is smaller, measuring 80–120 μ in diameter and 10–15 μ in height.

3. **Arcella mitrata** Leidy.

(Plate XV, figs. 9 and 10.)

Arcella mitrata Leidy in Proc. Acad. Nat. Sci. Phil. 1876, p. 76; *op. cit.* 1879, p. 162; and Freshw. Rhiz. N. Amer. (1879), p. 175, t. xxix (? excl. fig. 52); Corrado in Boll. Scient. I, an. 2 (1880), pp. 47, 48; Hitchcock Synops. Freshw. Rhiz. (1881), p. 26; Taránek in Sitz.-ber K. Böhm. Ges. Wiss. 1881 (1882), p. 225; Blochmann Mikr. Thierw. Süsswass (1886), p. 12, and ed. 2 (1895), p. 15; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 95; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 57; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 315; Penard Faune Rhiz. Léman (1902), p. 576, f. 8.

Test mitriform or balloon-shaped, ob-pyriform or polyhedral, higher than the breadth of the base, widest at or near the middle, more or less contracted or sloping inwardly towards the base; the dome mostly inflated, its summit and sides evenly rounded, or depressed into broad angular facets bounded by

prominent folds; base rounded at the border, inverted, concavely infundibuliform, mouth circular, crenulated, mostly everted within the inverted funnel. Plasma-body spheroidal, usually connected with the mouth by a cylindrical neck, and attached by threads of endoplasm to the interior of the test. Pseudopods variable in number, up to half a dozen or more.

Dimensions: Height of test 100–145 μ; diameter 100–152 μ (*West*).

Amongst *Sphagnum* and *Utricularia minor*, Cocket Moss, Giggleswick, West Yorkshire; and in *Sphagnum*-pools on Moel Siabod, North Wales (*G. S. West*).

Professor Leidy (whose description we quote) found this species abundant in some parts of Pennsylvania, but in Europe it seems very scarce. West (*loc. cit.*) remarks: "The mouth of the shell of this rhizopod is inturned into the cavity of the shell, forming a short, broad, tube-like mouth. Leidy figures the pseudopodia as arising from the body-protoplasm at the inner end of the tube; but in all the living forms observed, a ventral column of protoplasm passed from the body-protoplasm into this tube, completely filling it to the outer end. The pseudopodia then arose from the extreme ventral surface of this mass of protoplasm in the tube."

4. **Arcella dentata** Ehrenberg.

(Plate XV, figs. 7 and 8; and figs. 21–23 in text.)

Arcella dentata Ehrenberg in Abth. K. Akad. Wiss. Berlin, 1830 (1832), pp. 31, 40, 71; *op. cit.* 1831 (1832), p. 90; Infus. (1838), p. 134, t. ix, f. vii; and in Ber. K. Akad. Wiss. Berlin, 1853, p. 255; Pritchard Hist. Infus. (1842), p. 170; new ed. (1852), p. 211; and ed. 4 (1861), p. 155; Rymer Jones in Todd's Cycl. Anat. IV (1847), p. 10, f. 7, no. 2; Bailey in Smithson. Contrib. II (1851), art. 8, *passim*; Perty in Mitth. naturf. Ges. Bern. 1849, p. 163, and Kenntn. kleinst. Lebensf. (1852), p. 186; Leidy in Proc. Acad. Nat. Sci. Phil. 1874, p. 14; *op. cit.* 1876,

p. 56; and Freshw. Rhiz. N. Amer. (1879), p. 177, t. xxx, ff. 10–19; Maggi in Atti Soc. Ital. XXI (1878), pp. 314, 315; Parona in Boll. Scient. I, an. 2 (1880), pp. 47, 48; and *op. cit.* II, an. 6 (1884), p. 56; Hitchcock Synops. Freshw. Rhiz. (1881), p. 27; Taránek in Sitz.-ber. K. Böhm. Ges. Wiss. 1881 (1882), p. 225; Griffiths and Henfrey Micr. Dict. ed. 4 (1883), p. 70, t. xxx, f. 14 c; McMurrich in Proc. Canad. Inst. n.s. I (1883), p. 302; Blochmann Mikr. Thierw. Süsswass. (1886), p. 12; and ed. 2 (1895), p. 15; Whitelegge in Proc. Linn. Soc. N. S. Wales, (2) I (1886), p. 501; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 95.

Arcella stellaris Perty Mitth. naturf. Ges. Bern, 1849, p. 126; Penard Faune Rhiz. Léman (1902), p. 410, ff.

Arcella Okeni Perty Kenntn. kleinst. Lebensf. (1852), s. 186, t. ix, f. 4; Pritchard Hist. Infus. ed. 4 (1861), t. xxi, f. 15; Maggi in Atti Soc. Ital. XXI (1878), pp. 314, 315.

Arcellina dentata Carter in Ann. Nat. Hist. (2) XVIII (1856), p. 224.

Arcella stellata Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1871 (1872), p. 261, t. iii, f. 10.

Arcella Okeni var. Buck in Zeits. f. wiss. Zool. XXX (1878), p. 4, t. i, ff. a, d.

Test, in ventral and dorsal aspect, circular, and more or less dentated; in lateral view crown-like, the breadth more than twice the height; dome convex and even, or depressed at the summit and broadly fluted at the sides, the base centrally inverted, concavely infundibuliform; at the periphery more or less everted and divided into points of variable length. The mouth circular, entire. Protoplasm resembling that of *A. vulgaris*.

It is doubtful if typical *A. dentata* has been found in Britain, but we have met with a peculiar form much resembling Penard's figure ('Faune Rhiz. du Bass. du Léman,' p. 411), but differing from it in the shallower non-punctated test, and less robust spines. When viewed dorsally the spines radiated from the periphery of the membranous test; viewed laterally they were divergent, pointing upwards from the base.

Dimensions : Diameter 95 μ; length of spines 15–17 μ; mouth 30 μ diam.

Ponds in Cheshire, rare.

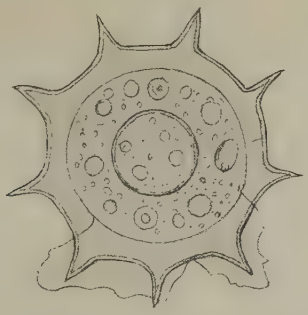
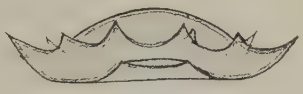


Fig. 21.—*Arcella dentata* (face view), a Swiss form, after Penard. × 250.

22

23



Figs. 22 and 23.—*Arcella dentata* (side views) : 22, a Swiss form, after Penard; 23, an American form, after Leidy. × 250.

5. **Arcella artocrea** Leidy.

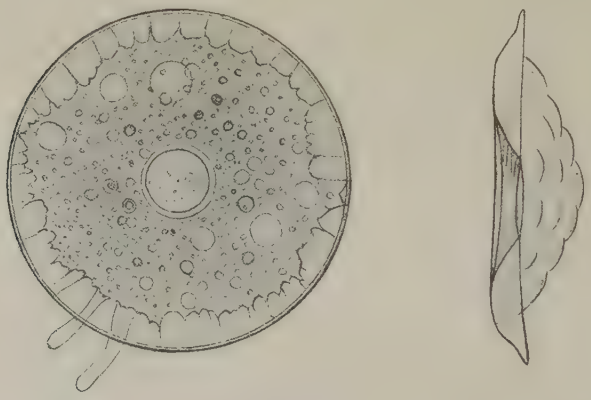
(Figs. 24 and 25.)

Arcella artocrea Leidy in Proc. Acad. Nat. Sci. Phil. 1876, p. 57; Freshw. Rhiz. N. Amer. (1879), p. 178, t. xxx, ff. 1–9; Corrado in Boll. Scient. I, an. 2 (1880), p. 47; Rolleston Forms Anim. Life, ed. 2 (1888), p. 901; Scourfield in Proc. Zool. Soc. 1897, p. 788; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 315, t. xxviii, f. 2; ? Penard Faune Rhiz. Léman (1902), p. 404, ff., and p. 665.

Test in height from one fourth to less than half the breadth; the dome convex and even, or mamillated, or pitted; basal border everted and rising from a quarter to nearly half the height of the test, obtusely

angular, and entire, the central portion of the base everted in the usual concavely infundibuliform manner; the mouth circular, entire, surrounded with a circle of minute tubercles. The plasma-body having the same general form and relationships as in other *Arcellæ*, but rendered bright green from the presence of abundance of chlorophyl-corpuscles in the endoplasm. Pseudopodia colourless, digitate.

Fig. 24. Fig. 25.



Figs. 24 and 25.—*Arcella artocrea* (face and side views), after Leidy. × 250.

Dimensions: Greatest breadth, 176 μ (*Leidy*).

Bog above the lakes at Capel Curig, North Wales; Co. Donegal, Ireland (*G. S. West*).

The species seems to be very rare, even in America. West (*loc. cit.*) found, in the locality above mentioned, a very large form, the diameter of the test (inclusive of the rim) measuring 300 μ; that of the mouth 32 μ; the height of the test being about 110 μ. Specimens from County Donegal, Ireland, were not more than 85 μ in diameter. Only empty tests were observed. The body of these was faceted, as in many of the more angular forms of *A. vulgaris*.

Genus 16. **PSEUDOCHLAMYS** Claparède & Lachmann, 1859.

Pseudochlamys Claparède & Lachmann Études Inf. et Rhiz. 2 (1859), p. 443.
Amphizonella Greeff in Arch. f. mikr. Anat. II (1866), p. 323.

Test discoid, flexible when young, protecting the plasma-body, which contains a central nucleus and several contractile vesicles.

This genus was established by Claparède and Lachmann (*loc. cit.*) to include a minute and highly-curious *Arcella*-like organism. Ordinarily the test is smooth, and, in the young state, quite transparent, but it becomes brown with age, most deeply coloured in the centre, and shading off towards the margin, sometimes appearing "faceted or punctate" according to these authors. Hertwig and Lesser ('Arch. für mikr. Anat.,' 1874) represent the concavity of the test, which in general shape resembles a watch-glass, as being closed, all but a central opening, by a delicate and hyaline continuation of the rim, completing the external resemblance to *Arcella*. Penard figures the same ('Faune Rhiz. du Bassin du Léman,' p. 181). The peripheral membrane is so exceedingly attenuated that the structure referred to is very difficult to make out. In the scores of empty tests we have examined, only in one instance did we find the faintest semblance of a central opening.

1. **Pseudochlamys patella** Claparède & Lachmann.

(Plate XVI, figs. 1–9.)

Pseudochlamys patella Claparède & Lachmann Études Inf. et Rhiz. 2 (1859), p. 443, t. xxii, f. 5; Carpenter Foram. (1862, *Ray Soc.*), p. 25; Hertwig & Lesser in Arch. f. mikr. Anat. X (1874), Suppl. p. 100, t. iii, f. 1; F. E. Schulze in Arch. f. mikr. Anat. XI (1875), p. 332, t. xviii, ff. 7-14; Allman in Journ. Linn. Soc., Zool. XIII (1877), p. 393, f. 3; Archer in Q. J. Micr. Sci. XVII,

n.s. (1877), p. 107, t. viii, ff. 1-3; Buck in Zeits. f. wiss. Zool. XXX (1878), pp. 5, 12; Maggi in Atti Soc. Ital. XXI (1878), pp. 314, 319, and in Boll. Scient. I, an. 2 (1880), p. 35; Bütschli in Bronn's Thier-Reichs, I, 1 (1880), t. ii, f. 8; Lanessan Traité Zool., Prot. (1882), p. 51, f. 39; Parona in Boll. Scient. I, an. 4 (1882), pp. 52, 56; Blochmann Mikr. Thierw. Süsswass. (1886), p. 12, t. i, f. 15, and ed. 2 (1895), p. 15, t. i, f. 11; Cattaneo in Boll. Scient. III, an. 10 (1888), p. 91; Sacchi in Boll. Scient. III, an. 10 (1888), p. 44; Longi in Atti Soc. Ligust. V (1894), p. 17; Delage & Hérouard Zool. concr. I (1896), f. 122; Calkins Prot. (1901), f. 13 c; Penard in Rev. Suisse Zool. IX (1901), p. 238, and Faune Rhiz. Léman (1902), p. 180, ff., and p. 666; Cash in Journ. Linn. Soc., Zool. XXIX (1904), p. 218.

Amphizonella flava Greeff in Arch. f. mikr. Anat. II (1866), p. 329, t. xviii, f. 19; Crevelli and Maggi in Rend. R. Ist. Lomb. (2) III, p. 369; Tripp in Proc. Bristol Nat. Soc. n.s. IV (1870), p. 19; Maggi in Atti. Soc. Ital. XXI (1878), p. 314.

Test discoid, generally circular, concave, in the young state hyaline and flexible, becoming rigid and brown with age; sometimes, in the latter condition, punctated on the convex surface, or, according to Archer, presenting an appearance of faceting or shagreening, "due to little rounded, closely-posted, scattered scrobiculi." The flexibility of the test, when young, is shown by its assuming a variety of forms, being at one moment discoid, at another folded in upon itself, wholly or partially, or rolled together scroll-like. A short finger-like pseudopod is sometimes protruded from between the folds. Nucleus central; contractile vesicles several, peripheral.

Dimensions: Diameter of test 40–45 μ.

Amongst submerged vegetation (*e. g. Hypnum fluitans*) in ponds, and amongst *Sphagnum*. In Cheshire ponds abundant, chiefly in the spring months, associated with *Microgromia socialis*.

The variations of figure of the test of *Pseudochlamys*, when young, correspond with the activities of the animal. There is a close attachment of the plasma-

body to the interior of the test, the latter appearing to be fully occupied, when the discoid figure is examined, except a narrow hyaline margin. Usually the animal begins an active movement by raising the margin of the test on the opposite side; the movement will be continued until the opposite margins approach and the figure becomes roughly-speaking semi-circular; or the margins will overlap, and the animal will remain thus curiously rolled together for some time, its general form being comparable to that of the chrysalis of a lepidopterous insect.

The discoid form admits of the endoplasm being readily studied. Four or more contractile vacuoles may usually be seen, pulsating languidly, on the outer margin of the plasma-body; and a central nucleus is also visible, though not conspicuous.

The brown colour of the test and its rigidity are distinctive of old individuals. Empty tests may at any time be met with where the species is abundant; they are seen to vary little, if at all, in size or structure. They differ widely in appearance from the tests of the *Arcellæ*, being very much smaller, simple, and concave, usually of a deep brown, and sometimes punctated about the centre, the colour gradually shading off towards the margin, which is rarely found inverted.

Although undoubtedly distinct, the affinities of *Pseudochlamys* are with *Arcella*. We have found the organism most abundant in spring, amongst floating *Hypna* in ponds. Later in the year it seems to disappear.

Genus 17. **CENTROPYXIS** Stein, 1859.

Arcella (pars) Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1830 (1832), p. 40.
Arcellina Canton in Ann. Nat. Hist. (1) IX (1842), p. 362.
Difflugia (pars) Perty in Mitth. nat. Ges. Bern, 1849, p. 45.
Centropyxis Stein in Abh. K. Böhm. Ges. Wiss. X (1859), Berichte, p. 43.
Echinopyxis Claparède and Lachmann Études Inf. et. Rhiz. 2 (1859), p. 447.

Test discoid, circular, or oval, with an excentric orifice; obtusely rounded posteriorly, where it is also thickest, thinning off towards the opposite edge, near which the mouth is situated. Mouth circular or oval, entire or with a sinuous or lobate border; the test furnished with a variable number of conical or curved, sometimes bifid, spines, its substance chitinous, exhibiting various shades of brown, or almost colourless; sometimes covered with extraneous elements (sand-grains, etc.) and without spines. The protoplasm colourless; pseudopodia digitate.

Leidy considered *Centropyxis* to be distinctly separated from *Arcella*, while on the other hand it appears closely related with *Difflugia*, through *D. constricta*. The relation is almost too close to justify the retention of the latter among the *Difflugiæ*.

The priority of *Centropyxis* over *Echinopyxis* is doubtful, but Stein's paper was *read* in 1857, and his name (*Centropyxis*) is the more appropriate one.

1. **Centropyxis aculeata** (Ehrenb.) Stein.

(Plate XVI, figs. 10–14.)

Arcella aculeata Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1830 (1832), p. 40; *op. cit.* 1831 (1832), p. 91; *op. cit.* 1841 (1842), p. 368, t. iii, f. 5; Infus. (1838), p. 133, t. ix, f. vi; in Ber. K. Akad. Wiss. Berlin, 1847, p. 477; and *op. cit.* 1853, p. 255; Pritchard Hist. Infus. (1842), p. 169, t. ii, ff. 92–94; new ed. (1852), p. 211, t. ii, ff. 92–94; and ed. 4 (1861), p. 555; Bailey in Smithson. Contrib. II (1851), art. 8, *passim*; Archer in Q. J. Micr. Sci. VI, n.s. (1866), pp. 185, 186.

Arcellina aculeata Canton in Ann. Nat. Hist. (1) IX (1842), pp. 362, 493.

Difflugia aculeata Perty in Mitth. nat. Ges. Bern, 1849, pp. 45, 162, and Kenntn. kleinst. Lebensf. (1852), p. 186; Leidy in Proc. Acad. Nat. Sci. Phil. 1874, p. 14; Maggi in Atti Soc. Ital. XXI (1879), p. 319.

Centropyxis aculeata Stein in Abh. K. Böhm. Ges. Wiss. X (1859), Ber. p. 43; Leidy Freshw. Rhiz. N. Amer. (1879), p. 180, t. xxxi, ff. 1–32; t. xxxii, ff. 29–34; in Proc. Acad. Nat. Sci. Phil. 1879, p. 163; and *op. cit.* 1880,

p. 338; Hitchcock Synops. Freshw. Rhiz. (1881), p. 28; Vejdovsky in Sitz.-ber. K. Böhm. Ges. Wiss. 1880 (1881), p. 136, and Thier. Org. Brunn. Prag (1882), pp. 32, 42, t. iii, ff. 8–14; Taránek in Sitz.-ber. K. Böhm. Ges. Wiss. 1881 (1882), p. 229; Bolton in Midl. Nat. IX (1886), p. 174; Whitelegge in Proc. Linn. Soc. N. S. Wales (2), I (1886), p. 501; Fielde in Proc. Acad. Nat. Sci. Phil. 1887, p. 122; Harvey in Amer. Nat. XXII (1888), p. 73; Zacharias in Biol. Centralbl. IX (1889), p. 60, etc.; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 149, t. v, ff. 21–37; in Arch. Sci. Phys. XXVI (1891), p. 143; in Rev. Suisse Zool. VII, 1 (1899), p. 40, etc., t. iv, ff. 1–4; *op. cit.* IX (1901), p. 237; and Faune Rhiz. Léman (1902), p. 302, ff.; Gruber in Zacharias' Tierwelt Süsswass. I (1891), p. 139, f. 16, no. 5; Perry in Proc. Amer. Soc. Micr. XII (1891), p. 95; Voeltzkow in Zool. Anzeig. XIV (1891), p. 225; Cash in Trans. Manch. Micr. Soc. 1891 (1892), p. 51; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 57; Levander in Zool. Anzeig. XVII (1894), p. 210; [Craig] in Amer. M. Micr. Journ. XVIII (1897), p. 101; Frenzel Mikr. Fauna Argent. I, Prot. 4 (1897), pp. 137, 148, t. x, ff. 14, 15, in Bibl. Zool. IV; Daday Mikr. Süsswass. Ceylon (1898), pp. 5, 9; Rhumbler in Arch. f. Entwick. VII (1898), p. 277, f. 70; Issel in Atti Soc. Torino, XXXVI (1901), pp. 64, 68, 273; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 315, t. xxix, ff. 15, 16; *op. cit.* XXIX (1903), p. 109; and in Ann. Scott. Nat. Hist. 1905, pp. 89, 92.

Echinopyxis aculeata Claparède and Lachmann Études Inf. et Rhiz. 2 (1859), p. 447; Carter in Ann. Nat. Hist. (3), XIII (1864), p. 29, t. i, f. 8; Parfitt in Trans. Devon Assoc. III. (1869), p. 67; Barnard in Proc. Amer. Assoc. XXIV (1876), p. 241, and in Amer. Q. Micr. Journ. I (1879), p. 83, t. viii, f. 3.

Arcella diadema Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1871 (1872), p. 259, t. iii, f. 7 (*non* 8).

? Echinopyxis hemispherica Barnard in Proc. Amer. Assoc. XXIV (1876), p. 242; and in Amer. Q. Micr. Journ. I (1879), p. 84, f. 2.

Centropsis [male pro *Centropyxis*] *aculeata* Parona in Boll. Scient. I, an. 2 (1880), pp. 47, 48.

Arcella (*Echinopyxis*) *aculeata* Griffiths & Henfrey Micr. Dict. ed. 4 (1883), p. 70, t. xxx, f. 14 *b*.

Echinopyxis australis Lendenfeld in Proc. Linn. Soc. N. S. Wales, X (1885), p. 724.

Test chitinous, variable in size and contour; usually carrying from four to six well-developed, curved, and occasionally bifid spines; opaque or semi-transparent, with an irregularly margined orifice, and not infrequently covered wholly or partially with fine sandy particles, or diatom shells; the excentric mouth being always at the shallow extremity. Endoplasm and pseudopodia as in *Difflugia*; the latter sometimes knotted or branching.

When encisted the protoplasm forms a spherical ball in the thicker part of the test; it is filled with granular matter and green or colourless globules.

Dimensions variable: Diameter of test 110–150 μ; length of spines 20 μ or more. Diameter of mouth 50–60 μ.

In ponds and ditches and amongst *Sphagnum* and wet moss, associated with *Difflugia*, etc.; frequent.

The species may readily be distinguished from *Difflugia constricta* by its larger size and more expanded outline, as well as by the branching of the pseudopodia. It is usually most plentiful amongst wet *Sphagnum* in swampy ground. Examples occurring in such situations are, as a rule, free from extraneous matter, except diatom shells, of which in some cases they appear as if built up. Those without incrustations have an irregular and delicate mesh-work on the chitinous surface and usually have the longest spines.

Examples vary greatly in size. West (in 'Journ. Linn. Soc.,' Zool., vol. xxviii) records individuals from Athry Lough, W. Ireland, measuring 450 μ without the spines. The transparent chitinous test sometimes exhibits a cancellated or punctated surfacing. Some Terrington Carr examples were found by the same author to be of a pale yellow colour and minutely scrobiculate. The scrobiculations were irregularly disposed, being scattered more or less in groups, and between them were numerous much smaller punctulations.

Var. **spinosa** *var. nov.* (Plate XVI, fig. 15, and fig. 26 in text.)

Test purely chitinous, without adherent sand-grains, semi-transparent; yellowish brown when young, turning to a darker brown with age (like *Arcella vulgaris*), and often partially or wholly covered with diatom-frustules. The mouth lobate or of unequal outline, variable in width, the margin sometimes slightly inverted. Spines variable in number and also in length, of the same substance as the test, and frequently curved.

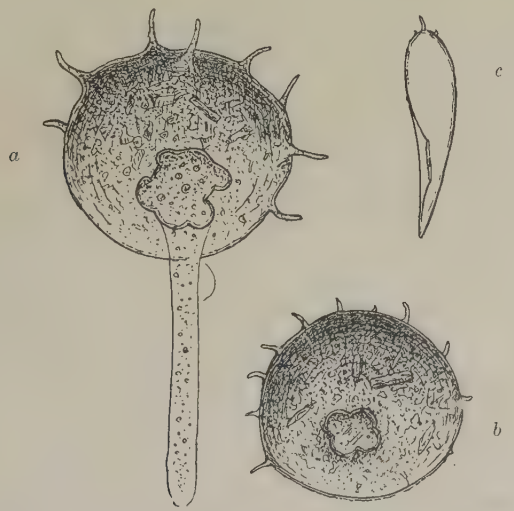


Fig. 26.—*Centropyxis aculeata* var. *spinosa*. *a*, a well-developed form; *b*, an example showing variation; *c*, lateral view of this form (in outline). From Dunham Marsh, Cheshire. × 260.

Dimensions: Diameter in face view 120–140 μ; greatest width in side view 30–40 μ.

In *Sphagnum*; frequent in Cheshire and North Wales.

This variety seems to have been regarded by most observers as indistinguishable from the type. We are, however, of opinion that the structure of the test, its more numerous spines, and particularly the lobate

mouth, are characters which justify the separation of this form under a varietal name. In our experience it most frequently occurs in wet *Sphagnum*. The variety is further distinguished from the type by its being more compressed and altogether more delicate in appearance.

With regard to *C. aculeata* and its varieties, it must be confessed there is not a little ambiguity. Forms are met with, chiefly in *Sphagnum*, which differ widely not only from the type, but also from each other, both in size and contour. Some are scarcely larger than average examples of *Difflugia constricta*, and differ so little from that species as to be almost indistinguishable; there is, in fact, a gradation of forms connecting the two species (*C. aculeata* and *D. constricta*), so numerous that it would be a difficult and not very profitable task to single them out for specific mention.

Var. **ecornis** (Ehrenb.) Leidy. (Plate XVI, fig. 16.)

Arcella ecornis Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1841 (1843), p. 368, t. i, f. 9; t. iii, f. 46; in Ber. K. Akad. Wiss. Berlin, 1845, p. 307; *op. cit.* 1848, pp. 215, 226; and *op. cit.* 1853, p. 178; Pritchard Hist. Infus. new ed. (1852), p. 212, and ed. 4 (1861), p. 555.

Arcella diadema (pars) Ehrenberg in Abh. K. Akad. Wiss. Berlin, 1871 (1872), p. 259, t. iii, f. 8.

Centropyxis ecornis Leidy in Proc. Acad. Nat. Sci. Phil. 1879, p. 163; Taránek in Sitz.-ber. K. Böhm. Ges. Wiss. 1881 (1882), p. 229; Vejdovsky Thier. Org. Brunn. Prag (1882), pp. 32, 43, t. iii, ff. 1–7; Fielde in Proc. Acad. Nat. Sci. Phil. 1887, p.122; Lord in Trans. Manch. Micr. Soc. 1891 (1892), p. 57; Frenzel Mikr. Fauna Argent. I, Prot. 4 (1897), p. 146, t. ix, ff. 13–15, in Bibl. Zool. IV.

Centropyxis aculeata var. *ecornis* Leidy Freshw. Rhiz. N. Amer. (1879), p. 181, t. xxx, ff. 20–34; t. xxxi, ff. 33, 34; t. xxxii, ff. 35, 36; Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 150, t. v, ff. 45–48; G. S. West in Journ. Linn. Soc., Zool. XXVIII (1901), p. 317.

Test of the same general structure as the type, but usually smaller; spineless.

Less common than the type, but not infrequently met with in swampy ground. Very abundant amongst damp moss on limestone rocks, Ingleton; also near Bowness, Westmoreland (*G. S. West*).

This variety seems to be the *Arcella ecornis* of Ehrenberg, properly removed by Leidy from that genus to *Centropyxis* as a variety of *C. aculeata*. Except for its usually smaller size it might be regarded as typical *C. aculeata* deprived of its spines. From *Arcella* it differs essentially in its test, which, as a rule, is heavily encrusted with sand-grains; whilst from *C. lævigata* Penard, it is at once distinguished by the character of the orifice, which is plain and not invaginated.

2. **Centropyxis lævigata** Penard.

(Fig. 27.)

Centropyxis lævigata Penard in Mém. Soc. Phys. Genève, XXXI, no. 2 (1890), p. 151, t. v. ff. 42–44, 49–55, and Faune Rhiz. Léman (1902), p. 306, ff, and p. 666.

Test in face view nearly circular, usually slightly compressed on one side, composed of chitinous material, and covered with irregular surface-scales and an admixture of fine sandy or muddy particles, causing opacity; the mouth obliquely invaginated, its outer margin broadly rounded, the orifice (terminating the inverted neck) excentric and generally invisible. In side view the outline of the test is nearly hemispherical, being broader at the posterior extremity. In this aspect it has some resemblance—helped by the surface-markings—to some forms of *Difflugia arcula*, from which, however, the character of the mouth and the inverted neck at once distinguish it.

Dimensions: Diameter in face view about 100 μ (120–135 μ, *Penard*).

In *Sphagnum*; at Dunham and Chelford, Cheshire, and near Abergynolwyn, North Wales.

The test of *C. lævigata* is not infrequently met with in *Sphagnum* from the localities indicated, but from its general opacity and resemblance to full-sized individuals of *Difflugia arcula*, is liable to be passed by. The rounded margins of the oral orifice, and the obliquely inverted neck, are sufficiently characteristic features.

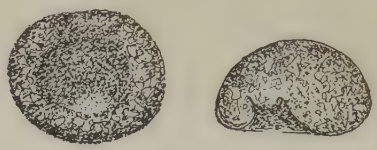


Fig. 27.—*Centropyxis lævigata* (face and lateral views). In *Sphagnum* from Dolgoch, Merionethshire. × 260.

Penard describes two other species of *Centropyxis*, *C. delicatula* and *C. arcelloides*, both smaller than that under notice, and having more or less external resemblance to *Arcella vulgaris*. They differ from *C. lævigata* in the structure of the mouth and other features.

Genus Arcella (see pp. 118–121).

Arcella vulgaris var. **compressa** var. nov. (Fig. 28.)

Arcella vulgaris (pars) Leidy Freshw. Rhiz. N. Amer. (1879), pl. xxviii, ff. 6, 7.
Arcella artocrea Penard Faune Rhiz. Leman (1902), p. 405, ff. (Non *A. artocrea* Leidy, 1879.)

Test composed of thin chitinous membrane, yellowish brown and semi-transparent, becoming darker with age, and faintly punctated. In face view discoid, irregularly oval, or sub-quadrate with rounded angles, never truly circular; with a centrally-situated, comparatively small oval mouth. In side view the crown

is compressed, its surface is parallel to the base and almost half its width. The lateral margins form six or eight obtusely-angular facets, the divisions of which are faintly distinguishable in face view; the neck is broadly inverted and extends upwards into the cavity of the test to about one third the distance separating the base from the crown.

Dimensions: Diameter in face view averaging 100 to 120 μ; from base to crown in side view about 45 μ.

In *Sphagnum* from Dolgoch, Merionethshire, Aug., 1905.

This variety is one of the numerous forms figured by Leidy under the general name of *Arcella vulgaris*, but is so distinct, and so evidently a permanent form, that its separation as a variety approaching *A. angulosa* is desirable. Penard figures it (*loc. cit.*) as a European form of *A. artocrea*, but this species, according to Leidy, though pitted with surface-depressions, has an arched crown. G. S. West also ('Journ. Linn. Soc.,' Zool., vol. xxviii) figures it thus.

Arcella vulgaris var. *compressa* is rare. We have only met with it in Merionethshire.

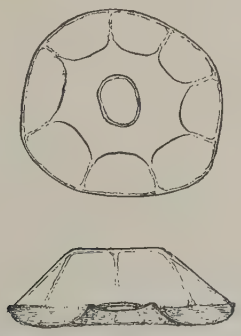


Fig. 28.—*Arcella vulgaris* var. *compressa* (face and lateral views, in outline). In *Sphagnum* from Dolgoch, Merionethshire. × 260.

Order Amœbina. Family Reticulosa.

Genus Chlamydomyxa (see pp. 91–94).

2. **Chlamydomyxa montana** Ray Lankester.

(Figs. 29–32.)

Chlamydomyxa Ray Lankester in Nature, XXXIV (1886), p. 408.

Chlamydomyxa montana Ray Lankester in Q. J. Micr. Sci. XXXIX, n.s. (1896), p. 233, tt. xiv, xv; Penard in Arch. f. Protisten-Kunde, IV (1904), p. 296, ff.

Chlamydomyxa labyrinthuloides (pars) Hieronymus in Hedwigia, XXXVII (1898), t. ii, ff. 23–25; Jenkinson in Q. J. Micr. Sci. XLII, n.s. (1899), f. f.

Body initially a rounded or ovoid particle of yellowish-green or brownish protoplasm, about 50 μ in diameter, resembling an *Amœba* at rest; the endoplasm densely crowded with pigmented corpuscles, rendering it nearly opaque; surrounded by a light-greyish or colourless border of granular-looking ectoplasm, from which, at different points, when the animal begins to move, pseudopodia are slowly emitted. Usually the body becomes ellipsoid, and pseudopodal development takes place at each extremity; the body gradually elongates and the ribbon-like pseudopodia break forth into extremely fine filaments, "apparently extruded from the general mass" (Lankester). They may be straight and rigid, or gently curved, and are susceptible of movement from side to side. The pseudopodia occasionally anastomose, and the fine filaments also have a tendency to unite; and they may sometimes branch or bifurcate. The animal is sensitive to any disturbance. When active it will vary in form from sub-spherical to ovoid or sub-triangular, the ends, or angles, being the points where the larger masses of filaments originate. Simultaneously with these move-

ments, and probably as a result of them, numerous vacuoles (non-contractile) appear in the substance of the ectoplasm about the bases of the pseudopodia.

During the activity of the animal there is a constant movement of minute fusiform colourless bodies (similar to, but smaller than those observed in *C. labyrinthuloides*), up and down the finely-attenuated threads, the precise function of which (as in *C. labyrinthuloides*) has not been satisfactorily determined. Prof. Lankester

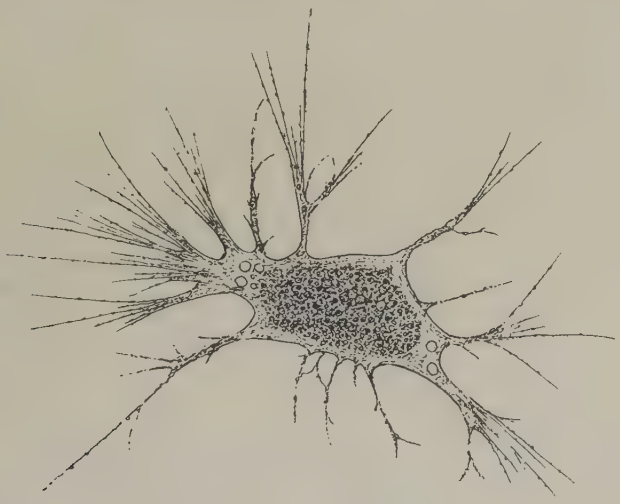


Fig. 29.—*Chlamydomyxa montana.* An individual extended and active. Chelford; September, 1905. × about 400.

was of opinion that they might consist of nuclear substance, "the particles of a fragmented scattered nucleus," but more recent researches by Dr. Penard have resulted in the discovery of true nuclei (which are numerous) in the pigmented substance of the endoplasm. They are spherical, very pale, and average 2·75 μ in diameter. Spherical cists are formed, several of which may be enclosed in a common cellulose envelope. A fragmentation of the plasma takes place, and there is a formation of secondary cists; these are liberated in due time, and undergo separate develop-

ment; and each exhibits in its own substance the elements characteristic of the parent, with true nuclei. The primary cist does not always proceed to fragmentation; the enclosed protoplasm may burst its envelope and resume active life (Penard).

Dimensions: Diameter of body (initial state) about 50 μ; length when extended (ovoid) 100–150 μ; inclusive of the pseudopodia 300 μ or over.

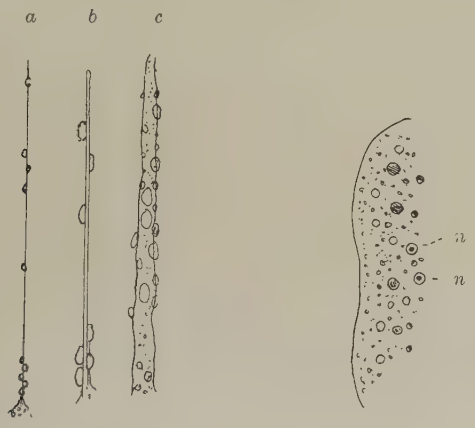
In a boggy pool at Chelford, Cheshire, associated with *Cochliopodia*, *Hyalodiscus rubicundus*, and other Rhizopoda, amongst floating vegetation, Sept., 1905.

Our practical acquaintance with this species is confined to two or three individuals met with whilst the preceding pages were passing through the press. With such inadequate material there was no opportunity for careful study, but this is the less to be regretted as the descriptions given by Ray Lankester and Penard are so exhaustive. For the particulars here given we are largely indebted to these authors.

Chlamydomyxa montana first became known through the investigations of Professor Lankester. Repeated search for *C. labyrinthuloides* was fruitless, but in August, 1886, he succeeded in finding on *Sphagnum* in ditches, cut in a bog which occupies a clearing in the pine-wood at Pontresina, the form afterwards described under the name of *C. montana*. It was met with by him on two subsequent visits to Switzerland. In each case the *Sphagnum* was old and in a state of incipient decay. It is to be noted that neither in our own experience, nor in that of Dr. Penard, was the animal met with in *Sphagnum*. The latter discovered it near Geneva, in marshy ground, associated with a species of aquatic *Hypnum*. In our only known English locality it was found in a pool, amongst some flocculent surface-vegetation which harboured a great variety of Desmidiæ, as well as much rhizopodous life, including such species as *Hyalodiscus rubicundus*, *Cochliopodium bilimbosum*, *Difflugia corona*, *D. amphora*, and various

Amœbæ, showing that *Sphagnum* is not essential to its existence. Moreover Dr. Penard was more fortunate than Dr. Lankester in being able, from the abundant examples which he found, to trace its life-history.

Dr. Lankester, in his article in the 'Quarterly Journal of Microscopical Science,' was able to give a full description of *C. montana* in its active phase. Its most striking peculiarity was found in the threads, and the "oat-shaped corpuscles" by which they were



30 31

Fig. 30.—Pseudopodal filaments of *C. montana*: *a*, an entire filament; *b*, a portion of the same, more highly magnified; *c*, a filament on which is a mass of ectoplasm, containing vacuoles. After Penard.

Fig. 31.—A fragment of the body of *C. montana*, under pressure, showing contained granules, vacuoles, and two nuclei (*n*); very highly magnified. After Penard.

traversed (fig. 30); these corpuscles being, according to Archer, one of the leading characteristics of his *C. labyrinthuloides*, and comparable to the nucleated spindle-shaped bodies which travel upon the threads of the *Labyrinthula* of Cienkowski. The threads are of extreme tenuity. "I never," he says, "saw any thread either fuse with a neighbouring thread or divide into two. It appears to me (but the observation is difficult) that when two threads come together they may be very closely apposed, but nevertheless retain

their distinctness; and conversely that when a thread seems to divide into two, longitudinally, the case is really one of separation of two pre-existing threads." His general conclusion was that the threads do not form a dendritic branching figure, or a network, but are merely apposed so as to form one less expanded, or, to speak more accurately, an apparent meshwork, and when more straightened and separated from one another, an apparent tree-like structure, the appearance in both cases being illusive.

Dr. Penard, however, having given close attention to the filaments and their behaviour, is of opinion that a real fusion is effected. The power of each filament to bifurcate he also placed beyond question.

With regard to the fusiform hyaline corpuscles which travel along the threads, Dr. Lankester says: "The movement of the oat-shaped corpuscles is the most interesting and characteristic feature presented by *Chlamydomyxa*. It must be distinguished altogether from the straightening and expanding movement of the mass of filaments; at the same time, it is not manifested until the filaments have become—some at least of them—straightened and free. Then as such a filament spreads itself, and as it were slowly pushes itself forth in a straight line, first one, then another, and finally many of the oat-shaped corpuscles are seen to advance along it. They move slowly in one direction as a rule, stopping sometimes after a considerable advance, and then resuming movement. They do not all travel at the same rate on one filament. I saw on several, one corpuscle overtake another and glide over the back (so to speak) of its more slowly-moving companion, and advance in front of it." He was of opinion that the movement was produced by an exceedingly delicate coat of hyaline protoplasm.

These minute bodies differ from those of *C. labyrinthuloides* in being considerably smaller, and generally ovoid. They are colourless, and Penard says resist the action of carmine and other reagents. Their

average length scarcely reaches 2 μ. They never, on meeting, fuse one with another.

The endoplasm of *C. montana* is filled with minute pigmented corpuscles. It is these which give the body its yellow-brown colour. Diatoms and small algæ are also often present in the general mass.

Dr. Penard found cists of *C. montana* of two kinds—namely, temporary cists, and cists proper, in which the organism maintains a latent existence for longer or shorter periods. The temporary cists, about 2 μ in diameter, have a transparent membranous envelope, usually colourless, but occasionally light yellow, and with a double contour. They are generally ovoid. The true cists are spherical; two or three together are sometimes found occupying a common cellulose envelope. Whilst *C. labyrinthuloides* rarely abandons its envelope, *C. montana*, in its active life, is invariably naked, and when encisted occasionally escapes from its cist (fig. 32), a mass of plasma issuing from an aperture—giving the organism the appearance of a testaceous rhizopod, with amœboid movements, and emitting filamentous pseudopodia rather copiously. More frequently there is a fragmentation of the contents of the cist, and from 20 to 40 globular secondary cists, about 18 μ in diameter, are liberated, to develop ultimately into living individuals, identical with the parent, but extremely minute.

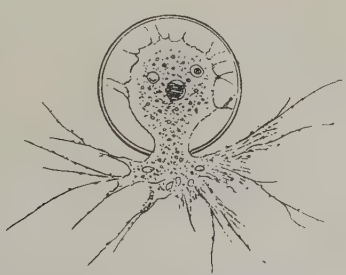


Fig. 32.—*C. montana*. A young individual issuing from its cist; highly magnified. After Penard.

INDEX

OF SPECIES, ETC., DESCRIBED IN VOL. I.

Synonyms in italics.

	PAGE
Amæba diffluens Maggi	43
guttula Maggi	55
princeps Maggi	44
radiosa Maggi	66
verrucosa Maggi	60
Amiba Bory	40
brachiata Duj.	65
diffluens Duj.	43
divergens Bory	41
guttula Duj.	54
Kœselii Crev.	43
limax Duj.	57
Mulleri Bory	42
princeps Duj.	43
radiosa Duj.	65
Rœselii Bory	41
verrucosa Duj.	59
Amœba *Ehrenb.*	40
actinophora *Auerb.*	48
brachiata Froment.	65
chaos Leidy	45
communis Duncan	45
diffluens Ehrenb.	42
gorgonia *Penard*	52
guttula *Duj.*	54
lateritia Fresen.	96
laureata Penard	80
limax *Duj.*	57
limicola *Rhumbl.*	56
natans Perty	59
oblonga Schmarda	43
papillata Mereschk.	60
pilosa *Cash*	62
polypodia Max Sch.	67
princeps Ehrenb.	42
Amœba *princeps* Carter	50
? princeps Czerny	75
proteus (*Pallas*) *Leidy*	41
var. granulosa *Cash*	48
? proteus Brayl.	75
quadrilineata Carter	59
radiosa Ehrenb.	64
Rœselii Pritch.	43
Rœselii (?) Carter.	43
sabulosa Leidy	79
striata *Penard*	53
? striolata Perty	53
terricola Greeff	60
verrucosa *Ehrenb.*	58
verrucosa Leidy	53
villosa *Wallich*	50
villosa Archer	83
villosa Slack	79
vitrea Penard	68
AMŒBINA	36
Amphizonella Greeff	129
flava Greeff	130
Arcella *Ehrenb.*	117
aculeata Ehrenb.	132
angulosa Perty	121
artocrea *Leidy*	127
costata Penard	121
dentata *Ehrenb.*	125
diadema Ehrenb.	133
discoidea Ehrenb.	122
discoides *Ehrenb.*	122
ecornis Ehrenb.	136
gibbosa Penard	121
hemisphærica Perty	120
mitrata *Leidy*	124

PAGE

Arcella *Okeni* Perty . . 126
patens Clap. & Lachm. . 120
peristicta Ehrenb. . 123
stellaris Perty . . 126
stellata Ehrenb. . . 126
viridis Perty . . 120
vulgaris *Ehrenb.* . . 118
var. angulosa (*Perty*) *Leidy.* . . 121
var. compressa *Cash* . 138
var. discoides Issel . 123
var. gibbosa (*Penard*) *G. S. West* . . 121
ARCELLIDA 115
Arcellina Canton . . 131
Arcellina Carter . . 117
aculeata Canton . . 132
dentata Carter . . 126
vulgaris Carter . . 120
Archerina *Ray Lank.* . . 112
Boltoni *Ray Lank.* . 113
Astramœba radiosa Vejdovs. . 66
Biomyxa *Leidy* . . 88
vagans *Leidy* . . 88
Centropsis aculeata Parona . 133
Centropyxis (*Ehrenb.*) *Stein* . 131
aculeata *Stein* . . . 132
var. ecornis (*Ehrenb.*) *Leidy* . . 136
var. spinosa *Cash* . 135
ecornis Leidy . . 135
lævigata *Penard* . . 137
Chaos Linn. . . . 40
protheus Linn. . . 41
Chlamydomyxa *Archer* . 91
labyrinthuloides *Archer* . 92
labyrinthuloides Hieron. . 140
montana *Ray Lank.* . 140
? Cochliopodium actinophorum Penard . . . 48
CONCHULINA . . . 37
Dactylosphæra polypodia Ray Lank. . . . 68

PAGE

Dactylosphæria polypodia Bütsch. . . . 68
radiosa Laness. . . . 66
radiosum Bütsch. . 66
Dactylosphærium *Hertw. & Less.* . . . 64
polypodium (*Max Sch.*) *Bütsch.* . . . 67
radiosum (*Ehrenb.*) *Bütsch.* 64
vitreum Hertw. & Less. . 68
Der Kleine Proteus Rösel . 41
Difflugia Perty . . 131
Difflugia Wallich . . 117
aculeata Perty . . 132
arcella Wallich . . 120
Echinopyxis Clap. & Lachm. . 131
aculeata Clap. & Lachm. . 133
australis Lendenf. . 133
? hemispherica Barnard . 133
Gymnophrys *Cienk.* . . 86
cometa *Cienk.* . . 86
Guttulidium guttula Frenz. . 55
Heliophrys Greeff . . 109
variabilis Greeff . . 110
varians G. S. West . 110
Heterophrys Archer . . 109
? myriapoda Archer . 110
varians F. E. Sch. . 110
Hyalodiscus *Hertw. & Less.* . 106
guttula Blochm. . . 55
limax Blochm. . . 57
rubicundus *Hertw. & Less.* 106
Leptophrys vorax Zopf . 102
Lithamœba *Ray Lank.* . 81
discus *Ray Lank.* . . 81
LOBOSA . . . 39
Mastigamœba *F. E. Sch.* . 69
aspera *F. E. Sch.* . . 70
var. cestriensis *Cash* . 72
ramulosa *Kent* . . 73
Nuclearia *Cienk.* . . 109
conspicua *G. S. West* . 112
delicatula *Cienk.* . . 109

	PAGE
Ouramœba *Leidy*	83
lapsa Leidy	84
villosa Ray Lank.	84
vorax *Leidy*	83
Pelobius Greeff	73
Pelomyxa *Greeff*	73
palustris *Greeff*	74
villosa *Leidy*	79
Penardia *Cash*	89
mutabilis *Cash*	90
Plakopus F. E. Sch.	106
ruber F. E. Sch.	106
Proteus O. F. Müll.	40
crystallinus Schrank	41
diffluens O. F. Müll.	41
Pseudochlamys *Clap.& Lachm.*	129
patella *Clap. & Lachm.*	129
RETICULOSA	85
RHIZOPODA	36
Saccamœba limax Frenz.	57
Saccamœba verrucosa Frenz.	60
villosa Frenz.	50
SARCODINA	36
Thecamœba quadripartita Froment.	60
Trichamœba hirta Froment.	50
Vampyrella *Cienk.*	95
flabellata *Cash*	103
gomphonematis *Hæck.*	105
lateritia (*Fresen.*) *Leidy*	96
pedata Klein	107
spirogyræ Cienk.	96
? variabilis Klein	102
vorax *Cienk.*	102
VAMPYRELLIDA	94
Vibrio O. F. Müll.	40
proteus O. F. Müll.	41
Volvox Linn.	40
chaos Linn.	41
proteus Pallas	41

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

EXPLANATIONS OF THE PLATES.

c. v. Contractile vacuole.
n. Nucleus.

Plate 1

PLATE I.

FIGS.

1, 2. *Amœba proteus* (Pallas) Leidy. (p. 41) Forms of a single individual. In fig. 1 the ectoplasm is represented as seen adhering to the cover-glass. Pond at Bangley, Cheshire. × about 400.

3. *A. proteus* var. *granulosa* Cash. (p. 47) In rapid movement. Hale Moss, Cheshire. × about 400.

4–6. *A. proteus*. Fig. 4.—Common pond form, the plasma-body appearing in two nearly equal masses with a connecting isthmus in which the contractile vacuole appears centrally situated. Figs. 5 and 6.—Two views of a smaller pond form, containing a *Navicula*. All × 300.

7–10. *A. actinophora* Auerb. (p. 48) Figs. 7 and 8.—Active and quiescent states. Pond at Chelford, Cheshire. Figs. 9 and 10.—Another individual exhibiting the same phases. From the same pond. All × 450.

West, Newman chromo

Plate 2

PLATE II.

Amœba villosa Wallich. (p. 50)

Figs.

1, 2. Two views of a large and active individual, the endoplasm containing various algæ and diatoms, besides chlorophyllose corpuscles. In fig. 2 the posterior villous organ is obscured. Pond at Baguley, Cheshire. × 300.

3, 4. Two views of another individual. From the same locality. × 300.

5, 6. A young individual. In fig. 6 the form represented was assumed upon agitation of the cover-glass. × 300.

7. Another example, containing a large *Navicula*. × 300.

AMŒBA.

J. Cash, del.

A.S. Huth, lith.

Plate 3

PLATE III.

FIGS.

1, 1 *a*. *Amœba limax* Duj. (p. 57) Fig. 1.—Ordinary form. Dunham Marsh, Cheshire. × 300. Fig. 1 *a*.—Details of characteristic caudal appendage. After Penard.

2. *A. proteus* var. *granulosa* Cash. (p. 47) Hale Moss, Cheshire. × about 400.

3–5. *A. gorgonia* Penard. (p. 52) In *Sphagnum*, pondside, Chelford, Cheshire. × 300. Fig. 3.—In a resting state. Fig. 4.—Active movement commenced, most of the pseudopodia withdrawn. Fig. 5.—The whole of the pseudopodia withdrawn, the animal exhibiting remarkable contortions during progression.

6–7 *a*. *A. striata* Penard. (p. 53) Figs. 6 and 7.—Two individuals differing in size. Pond at Northenden, Cheshire. × 400. Figs. 7 *a*, *b*.—The contractile vacuole (a peculiar form). After Penard.

8–11. *Dactylosphærium radiosum* (Ehrenb.) Bütschli. (p. 64) Figs. 8 and 9.—An individual of unusual form. In fig. 8 three arms are extended irregularly, each from a broad base; in fig. 9 one arm is partially retracted. In *Sphagnum*, Cheshire. × 300. Fig. 10.—The same form (?), after West. Fig. 11.—An uncommon inert form, exhibiting attenuated pseudopodia which are bent and in some cases spirally twisted. In *Sphagnum*, Knutsford Moor, Cheshire. × about 200.

12. *D. polypodium* (Max Sch.) Bütschli. (p. 67) After Hertwig and Lesser.

AMŒBA AND DACTYLOSPHÆRIUM.

J. Cash del. Wes. Newman sculpsit.

Plate 4

PLATE IV.

FIGS.

1–5. *Amœba pilosa* Cash. (p. 62) Figs. 1–3.—Typical form, as seen in three positions. Chelford, Cheshire. × 300. Figs. 4 and 5.—A possibly distinct form having the same pilose character, but of more sluggish habit, with a posterior lobe, and with the endoplasm more densely granular. The punctulations on the surface of the posterior lobe represent spiculæ which stand erect, presenting their extremities to the eye. Pond at Fearnhead, Lancashire. × 300.

6–11. *Dactylosphærium radiosum* (Ehrenb.) Bütschli. Figs. 6–8.—Phases of a single individual, representing a common type; in fig. 8 in rapid movement, with all the pseudopodia retracted. Dunham Marsh, Cheshire. × 300. Figs. 9 and 10.—Less frequent forms; 9, with numerous rigid, elongated, and sharply-pointed pseudopodia; 10, a large and peculiarly radiate example. Dunham Marsh. × 400. Fig. 11.—Another form, after West. × 480.

12. *D. polypodium* (Max Sch.) Bütschli. (p. 67) After Penard.

AMŒBA AND DACTYLOSPHÆRIUM.

West, Newman chromo.

Plate 5

PLATE V.

FIGS.

1–3 *a*. *Amœba verrucosa* Ehrenb. (p. 58) Fig. 1.—An individual in the resting phase, enclosing a rotifer. Perwick Bay, Isle of Man. × 300. Figs. 1 *a–c*.—A single young individual, general form subspherical, the body translucent, its surface wrinkled. In *Sphagnum*, Cheshire. × 300. Fig. 2.—An adult individual in the resting phase, containing much partially-digested food. Isle of Man. × 300. Fig. 3.—An individual seen during greatest activity. Heatley, Cheshire. × 300. Fig. 3 *a*.—Nucleus, after Penard. More highly magnified.

4. *A. guttula* Duj. (p. 54) Common form occurring in ponds amongst surface vegetation. × 400.

5. *Lithamœba discus* Ray Lank. (p. 81) Outline sketch, after Ray Lankester.

6. *Ouramœba voraæ* Leidy. (p. 83) After Leidy. × 200.

Plate 6

PLATE VI.

FIGS.

1–3. *Mastigamœba aspera* F. E. Sch. (p. 70) Fig. 1.—Ordinary appearance of an adult during forward movement. Pond at Chelford, Cheshire. Fig. 2.—An individual which, after passing through a variety of mutations, ejected a quantity of effete matter at the point *a*. The flagellum is not visible, though in the normal state it was distinctly seen (as in fig. 1). Fearnhead, Lancashire. Fig. 3.—A smaller example showing variation from the type. All × 400.

4. *M. aspera* var. *cestriensis* Cash. (p. 72) Northen Etchells, Cheshire. × 400.

5. *M. aspera*. An attitude not infrequently assumed when the animal is resting, showing a resemblance to some figures of *Dactylosphærium vitreum* Hertw. & Less. Chelford, Cheshire. × 400.

6. *M. ramulosa* Kent. (p. 73) Typical form, after Saville Kent. × 400.

MASTIGAMŒBA

J Cash del

West, Newman & Co. lith.

Plate 7

PLATE VII.

Figs.

1–3. *Pelomyxa palustris* Greeff. (p. 74) Fig. 1.—Ordinary condition during active movement. Pond at Northen Etchells, Cheshire. × about 100. Figs. 1 *a–d*.—Phases in development from amœbulæ, as observed by Greeff. Fig. 2.—A young individual in resting state, showing internal structure; after Greeff. × about 60–70. Fig. 3.—An unusual phase of resting state, the plasma-body forming a sub-spherical mass with a fringe of fine hyaline pseudopodia. × about 150.

4–6. *P. villosa* Leidy. (p. 79) Fig. 4.—Ordinary condition during activity. Fig. 5.—A somewhat larger individual in the same condition. Fig. 6.—A portion of the latter after undergoing various changes. By lateral extension of the body the posterior lobe became obliterated and the villi were spread out along the margin until the normal condition was reverted to. All × 250.

PELOMYXA.

J.Cash, del.

P.W.M.Trap impr.

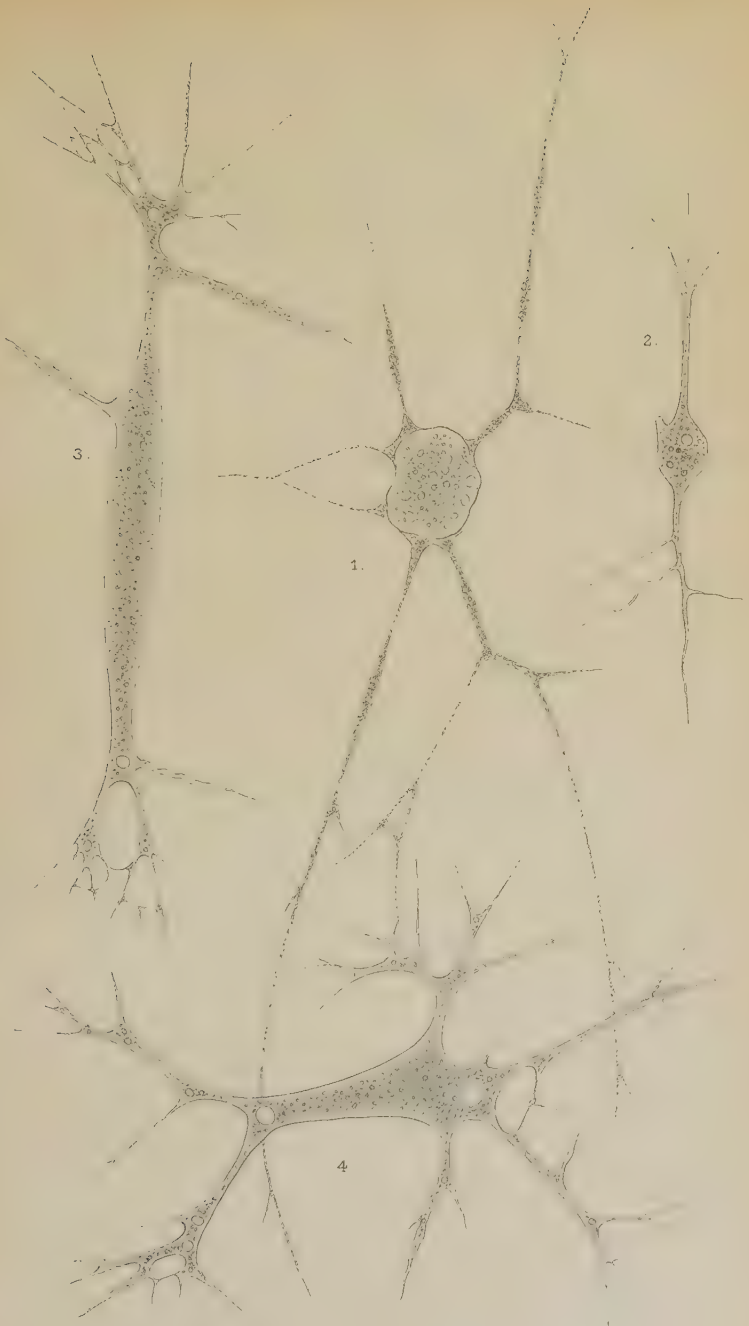
Plate 8

PLATE VIII.

Figs.

1, 2. *Gymnophrys cometa* Cienk. (p. 86) Fig. 1.—An example from wet *Sphagnum*, Lindow, Cheshire. × 300. Fig. 2.—After Penard.

3, 4. *Biomyxa vagans* Leidy. (p. 88) Views of a single individual showing forms assumed during active movement. In tufts of moss on moist rocks, Perwick Bay, Isle of Man. × 300.



GYMNOPHRYS AND BIOMYXA.

J. Cash, del.

P.W.M. Trap, impr.

Plate 9

PLATE IX.

Penardia mutabilis Cash. (p. 90)

Figs. 1–5.—Different phases of a single individual. Figs. 1 and 2.—The animal in active movement, the disposition of the pseudopodal filaments constantly changing. Figs. 3–5.—After capture of a rotifer; 3, the prey enveloped by sarcode processes; 4, most of the pseudopodal filaments withdrawn before complete absorption of the rotifer; 5, after its absorption, the rotifer being enclosed in the body-mass, and invisible. In wet *Sphagnum*, Epping Forest. × about 300.

PENARDIA.

West, Newman, chromo

Plate 10

PLATE X.

Vampyrella lateritia (Fresen.) Leidy. (p. 96)

Figs.

1-4. Ordinary form. Marshy pools, Cheshire. × 300. Fig. 1. —Showing capitate and pseudopodal rays. Fig. 2.— The same individual attached to a Conferva filament. Fig. 3.—The filament broken at a joint, one cell being emptied of its chlorophyl. Fig. 4.—After two cells have been cleared, showing the position in which the cells were left.

5. Liberation of a sporozoon, the pseudopodia of which are sharply pointed. × 300.

6, 7. Two views of the same sporozoon after complete separation, exhibiting amœboid movements and containing a vacuole and an apparent nucleus. (The further development could not be traced.) × 300.

8. A peculiar condition, the body covered with a mass of external vesicles (some pedunculated). Dunham Marsh, Cheshire. × 450.

9. An individual with two pulsating vesicles, fine radial filaments, and numerous short irregularly-crowded pseudopodia in place of capitate rays. Barking, Essex. × 450.

10. An individual at rest, after attacking a Conferva filament and absorbing the chlorophyl of one segment. Epping Forest. × 300.

P[illegible]ELLA.

West, Newman imp.

Plate 11

PLATE XI.

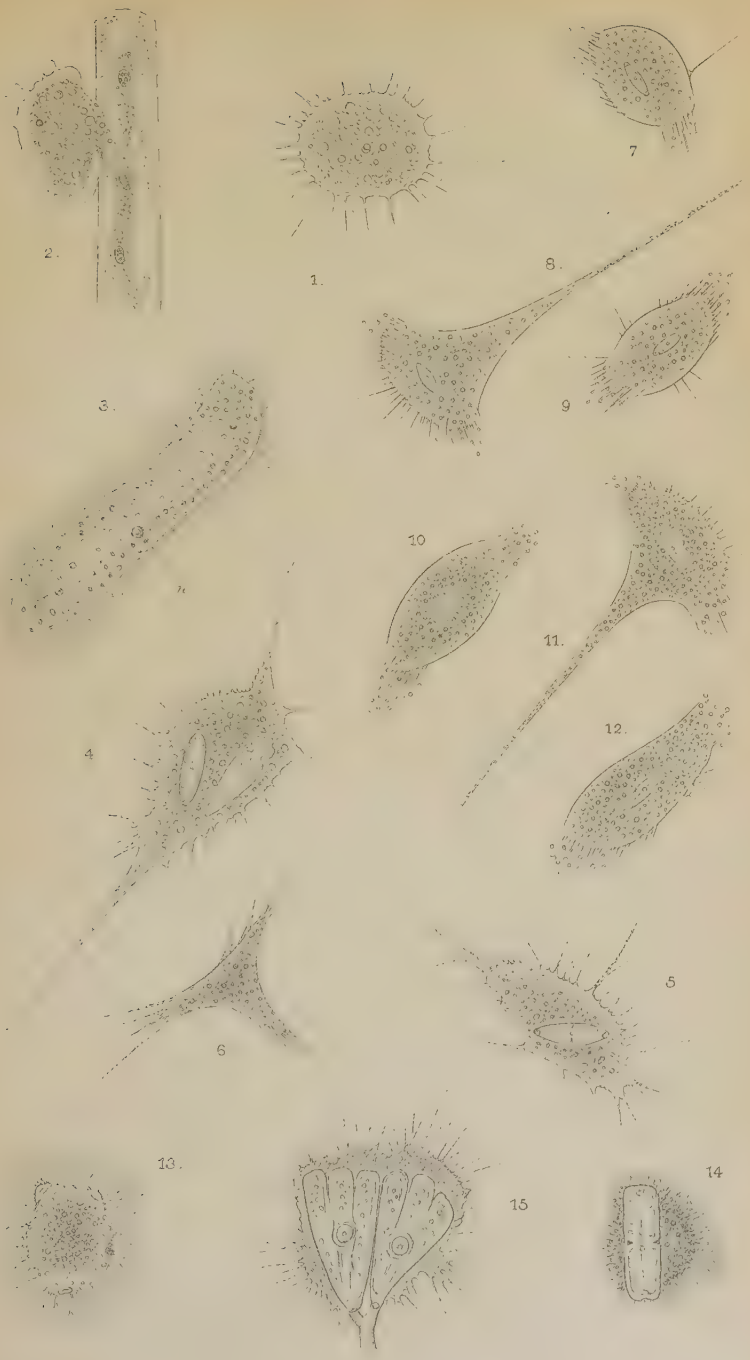
FIGS.

1–3. *Vampyrella lateritia* (Fresen.) Leidy. (p. 96) Fig. 1. —An individual with pseudopodia fully extended. After West. × 520. Fig. 2.—The same, after attacking a filament of *Mougeotia*. After West. × 520. Fig. 3.—Slug-like form. After Bütschli. × about 800.

4–6. *V. vorax* Cienk. (p. 102) Fig. 4.—A plasmodium formed by the union of two separate individuals, of which fig. 5 was one. Pond at Northen Etchells, Cheshire. × 500. Fig. 6.—An individual of unusual form. After Penard.

7–12. *V. flabellata* Cash. (p. 103) An individual as seen in various attitudes, during extended observation. Barking, Essex. × 500.

13–15. *V. gomphonematis* Hæck. (p. 105) Fig. 13.—An individual as ordinarily met with amongst floating vegetation. Pond, Cheshire. × 500. Fig. 14.—Another, enclosing a diatom from which it had extracted the chlorophyl. Pond, Cheshire. × 500. Fig. 15.—An example as seen enveloping frustrules of a *Gomphonema*. From Bütschli, after Hæckel. × about 350.



VAMPYRELLA.

Plate 12

PLATE XII.

Nuclearia delicatula Cienk. (p. 109)

Figs.

1, 2. Views of a single individual. Fig. 1.—Resting phase. Fig 2.—Body extended and in active movement. Each × 450.

3, 4. Resting (3) and active (4) phases of another individual. × 300.

5, 6. Resting (5) and active (6) phases of another individual. × 300.

7, 8. A young state (?) of this species. × 300.

All from ponds in Cheshire.

NUCLEARIA.

West, Newman, del. et lith.

Plate 13

PLATE XIII.

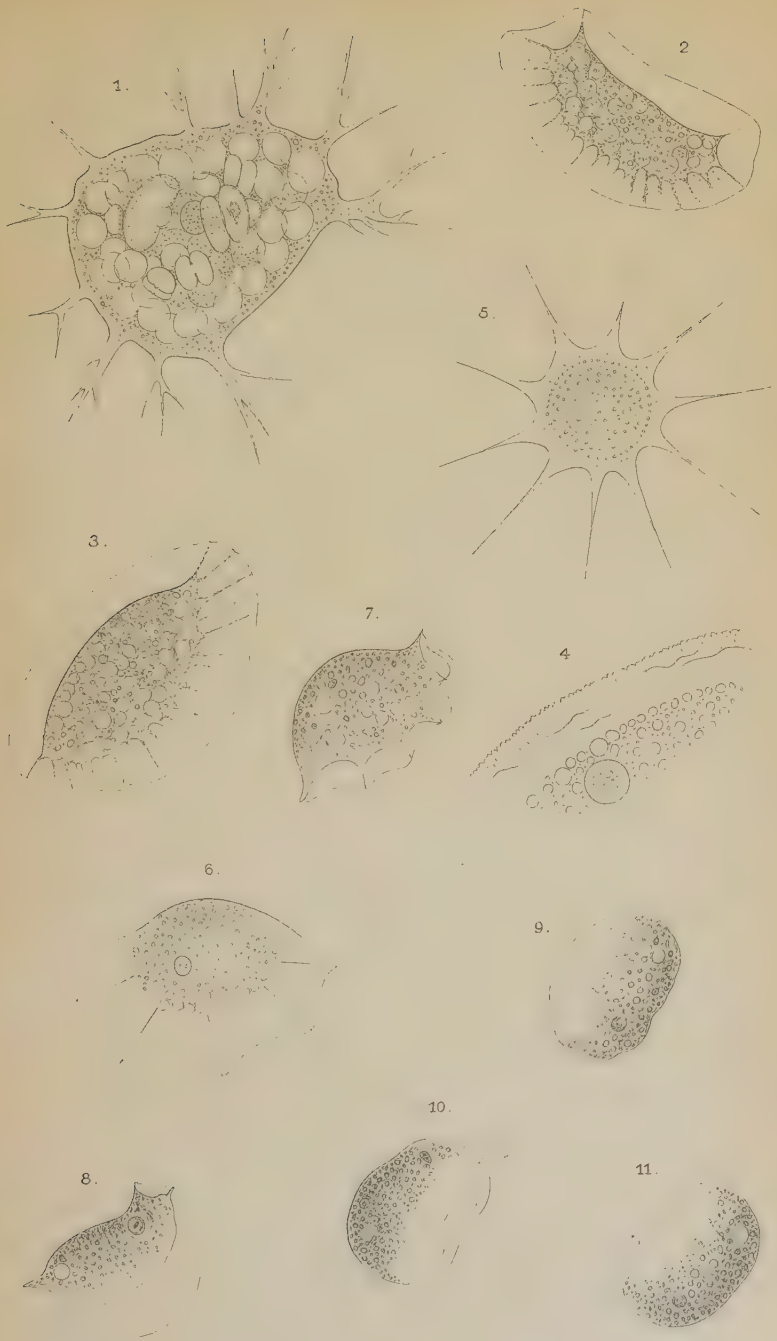
Figs.

1. *Nuclearia conspicua* West. (p. 112) An individual with pseudopodia extended. After West. × 400.

2–6. *Hyalodiscus rubicundus* Hertw. & Less. (p. 106) Figs. 2 and 3.—Views of single individual. Pond at Northen Etchells, Cheshire. × 500. Fig. 4.—Anterior margin. After Penard. Figs. 5 and 6.—Resting and active states. After Penard.

7. Form of *H. rubicundus* named *Plakopus ruber* by F. E. Schulze. After Schulze (reduced). × about 400.

8–11. Phases assumed by an individual probably identical with the above form. Epping Forest. × 500.



NUCLEARIA AND HYALODISCUS.

J.Cash del.

P.W.M Trap impr.

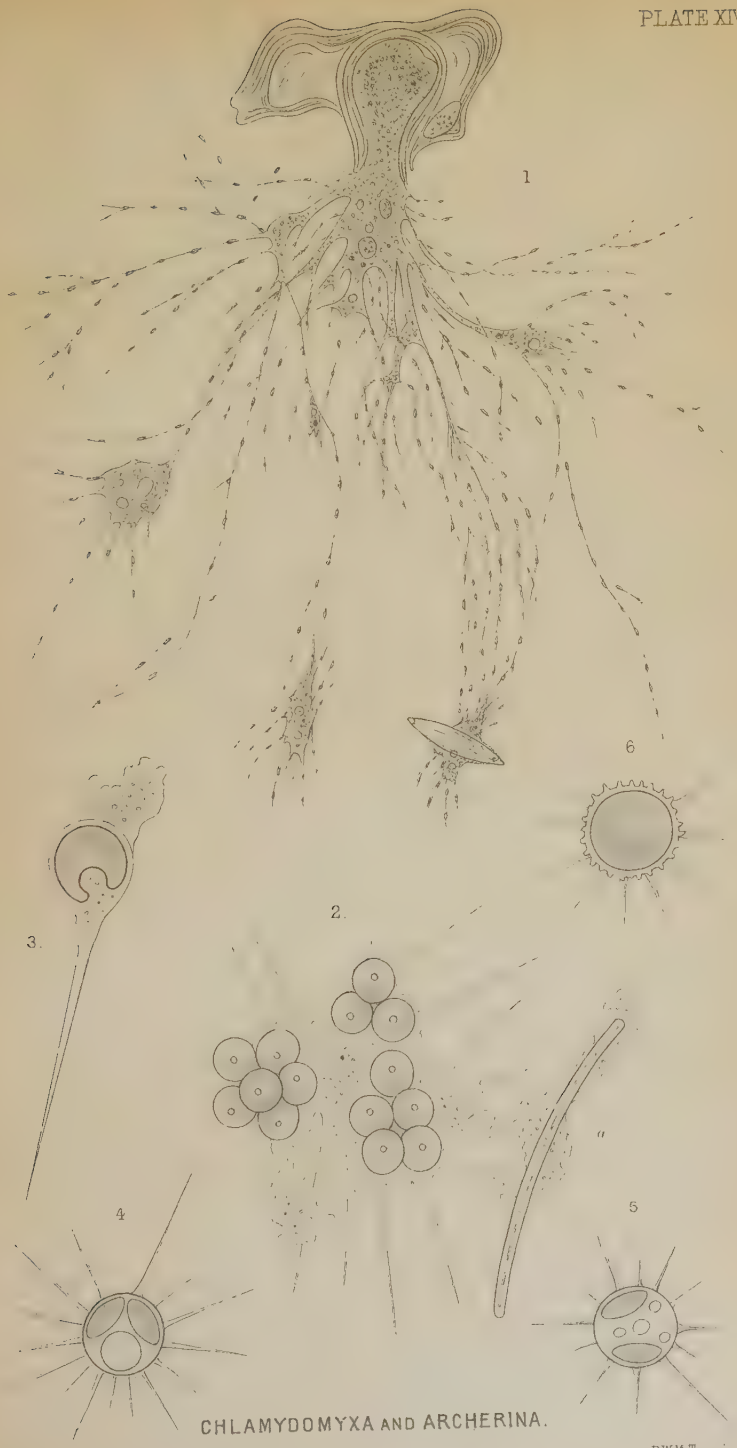
Plate 14

PLATE XIV.

Figs.

1. *Chlamydomyxa labyrinthuloides* Arch. (p. 92) An individual with widely-extending filamentous pseudopodia emerging from a cist. After Archer.

2–6. *Archerina Boltoni* Ray Lank. (p. 114) Fig. 2.—A colony of irregularly-grouped chlorophyl-corpuscles and protoplasm resulting from tetraschistic division of one original chlorophyl-corpuscle (as fig. 3), the abundant amœboid protoplasm actively ingesting a bacillus filament (*a*). Fig. 3.—An individual more highly magnified, with irregularly-shaped chlorophyl-corpuscle and protoplasm gathered into an amœboid lobe and a long filament. Figs. 4 and 5.—Examples of central spheres showing varying disposition of chlorophyl and vacuoles. Fig. 6.—An encisted individual. All after Ray Lankester.



CHLAMYDOMYXA AND ARCHERINA.

J.Cash. del.

P.W.M. Trap. impr.

Plate 15

PLATE XV.

Figs.

1–3. *Arcella vulgaris* Ehrenb. (p. 118) Pond, Cheshire. × 300. Fig. 1.—A young individual, in active movement, with transparent test. Figs. 2 and 3.—Empty tests of the same form.

4–6. *A. discoides* Ehrenb. (p. 122) Pond, Cheshire. × 300. Figs 4 and 5.—Lateral and dorsal views of living individuals. Fig. 6.—A young individual with imperfectly-formed test.

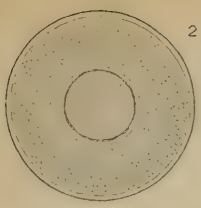
7, 8. *A. dentata* Ehrenb. (p. 125) Dorsal and lateral views, showing character of test. × 300.

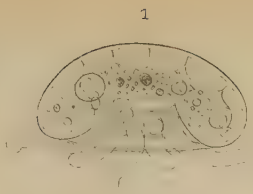
9, 10. *A. mitrata* Leidy. (p. 124) Dorsal and lateral views, after Leidy. × about 300.

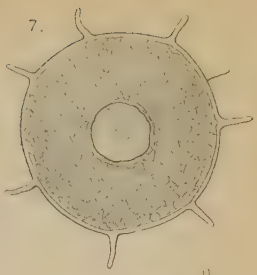
11, 17. *A. vulgaris* var. *gibbosa* (Penard) G. S. West. (p. 121) A small variety, with facetted test. Frequent in ponds. × 300.

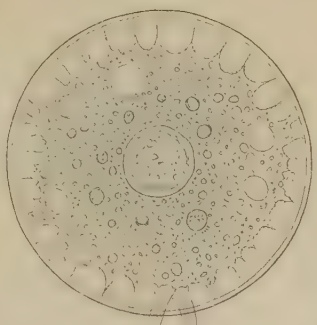
12, 16. *A. vulgaris* var. *angulosa* (Perty) Leidy. (p. 121) In outline, after Leidy. × 250.

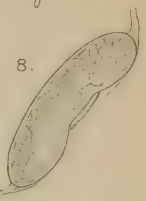
13–15. *A. vulgaris*. Figs. 13 and 14.—Dorsal and lateral views of a young individual; the test transparent, with dilated base. Fig. 15.—A remarkably fine variety, with pitted test. Pond at Park Bridge, Lancashire. × 300.

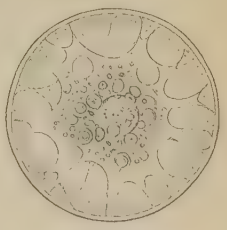


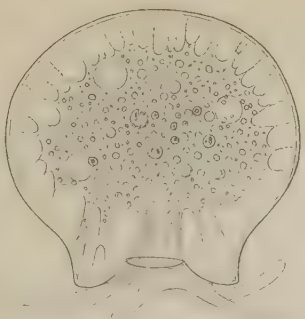


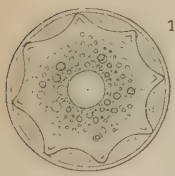


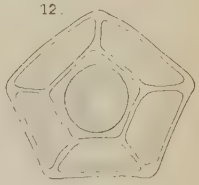


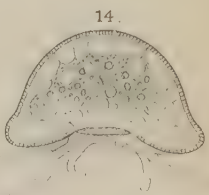


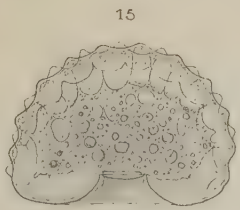












ARCELLA.

J.Cash, del. P.W.M.Trap, impr.

Plate 16

PLATE XVI.

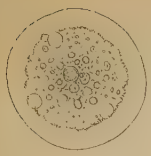
Figs.

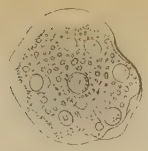
1–9. *Pseudochlamys patella* Clap. & Lachm. (p. 129) Fig. 1. —Ordinary discoid phase of an adult individual. Pond at Northen Echells, Cheshire. × 500. Figs. 2–4.—Phases of a young individual with pliable test. × 500. Fig. 5.—Another in the same stage of growth, inert, the margins of the test overlapping. × 500. Fig. 6.—An individual exhibiting a digitate pseudopod. × 500. Figs. 7–9.—Different aspects as figured by Claparède and Lachmann.

10–14. *Centropyxis aculeata* Stein. (p. 132) Fig. 10.—An empty test of the typical form. Fig. 11.—The same, viewed obliquely. Figs. 12 and 13.—Views of a living example, in different positions, and showing variation from the type. Fig. 14.—An encysted example. Dunham, Cheshire. All × 300.

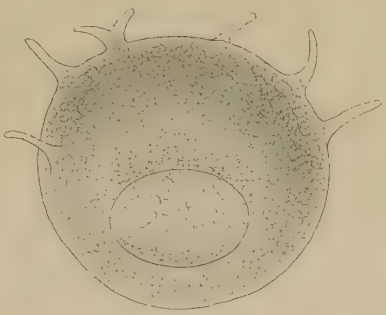
15. *C. aculeata* var. *spinosa* Cash. (p. 135) Dunham, Cheshire. × 300.

16. *C. aculeata* var. *ecornis* Leidy. (p. 135) An empty test, showing ordinary spineless character. Pond, Baguley, Cheshire. × 300.


1.


2.

3.

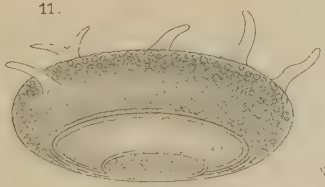

10.

4.

7.

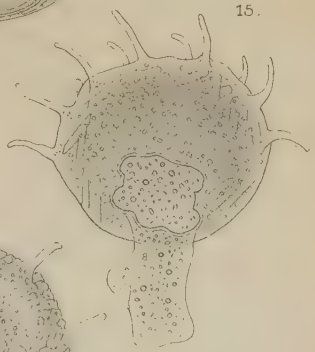
8.

5.

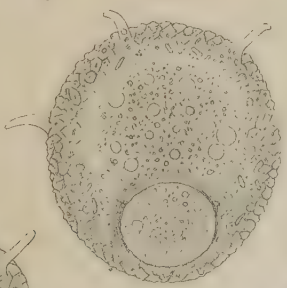

11.

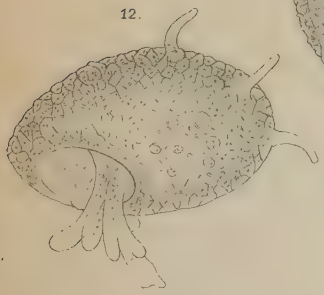
6.

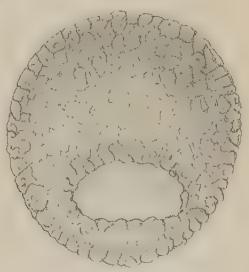
9.


15.

13.


14.


12.


16.

PSEUDOCHLAMYS AND CENTROPYXIS.

J.Cash del. P.W.M.Trap.impr.

RAY SOCIETY.

(INSTITUTED 1844.)

OFFICERS AND COUNCIL.

1905—1906.

President.

THE RT. HON. LORD AVEBURY, D.C.L., LL.D., PRES.SOC.ANT., FOR.SEC.R.A., F.R.S., F.L.S., ETC.

Vice-Presidents.

REV. CANON NORMAN, M.A., D.C.L., LL.D., F.R.S.
ALBERT D. MICHAEL, F.L.S., F.Z.S.
THE RT. HON. LORD WALSINGHAM, M.A., LL.D., F.R.S.

Council.

ROBERT BRAITHWAITE, M.D., F.L.S.
T. A. CHAPMAN, M.D., F.Z.S.
Rev. ALFRED FULLER, M.A., F.E.S.
SIDNEY F. HARMER, Sc.D., F.R.S.
Prof. W. A. HERDMAN, D.Sc., F.R.S., F.R.S.E., Pres.L.S.
B. DAYDON JACKSON, F.L.S.
ALBERT H. JONES, F.E.S.
HENRY LAVER, M.R.C.S.
J. W. S. MEIKLEJOHN, M.D., F.L.S.
J. S. PHENÉ, LL.D., F.S.A.
Prof. EDWARD B. POULTON, M.A., Sc.D., LL.D., F.R.S.
HENRY POWER, M.B., F.L.S., F.Z.S.
P. H. PYE-SMITH, M.D., B.A., F.R.C.P., F.R.S.
D. H. SCOTT, M.A., Ph.D., F.R.S., F.L.S., Pres.R.M.S.
HENRY SPICER, B.A., F.L.S., F.G.S.
ALFRED O. WALKER, F.L.S., F.Z.S.

Treasurer.

F. DUCANE GODMAN, D.C.L., F.R.S., F.L.S., F.G.S.

Secretary.

JOHN HOPKINSON, F.L.S., F.G.S., V.P.R.Met.Soc., Assoc. Inst.C.E., Weetwood, Watford.

LIST OF THE SOCIETY FOR 1905.

Additions to the List of October.

November, 1905.

Bristol Naturalists' Society ; 20 *Berkeley Square, Bristol.*

Chicago, University of ; *Chicago, Ill., U.S.A.*

Liverpool School of Tropical Medicine ; *Exchange Buildings, Liverpool.*

New South Wales, Public Library of; *Sydney, New South Wales.*

Porter, R. H. ; 7 *Princes Street, Cavendish Square, W.*

Storey, John Edward ; 26 *Grosvenor Road, Whalley Range, Manchester.*

RAY SOCIETY.

ANNUAL SUBSCRIPTION ONE GUINEA.

RECENTLY ISSUED AND FORTHCOMING MONOGRAPHS.

For the Sixty-first Year, 1904.

A Monograph of the British Desmidiaceæ. By W. WEST and G. S. WEST. Vol. I. xxxvi + 224 + 64 pp., 32 plates. 8vo. 1904.

The British Tunicata. By the late JOSHUA ALDER and the late ALBANY HANCOCK. Edited by JOHN HOPKINSON, with a history of the work by the Rev. A. M. NORMAN. xvi + 148 + 40 pp., 20 plates, and frontispiece. 8vo. 1905.

For the Sixty-second Year, 1905.

A Monograph of the British Desmidiaceæ. By W. WEST and G. S. WEST. Vol. II. x + 206 + 64 pp., 32 plates (xxxiii–lxiv). 8vo. 1905.

The British Freshwater Rhizopoda and Heliozoa. By JAMES CASH, assisted by JOHN HOPKINSON. Vol. I. The Rhizopoda, Part I. x + 150 + 32 pp., 16 plates. 8vo. 1905.

In Course of Publication.

The British Annelids. By Prof. W. C. MCINTOSH.

The British Desmidiaceæ. By W. WEST and Prof. G. S. WEST.

The British Freshwater Rhizopoda and Heliozoa. By JAMES CASH.

The British Tunicata. By the late JOSHUA ALDER and the late ALBANY HANCOCK.

Preparing for Publication.

The British Centipedes and Millepedes. By WILFRED MARK WEBB.

The British Characeæ. By HENRY and JAMES GROVES.

The British Parasitic Copepoda. By Dr. THOMAS SCOTT and ANDREW SCOTT.

The British Sphagnaceæ. By E. C. HORRELL.

593.11 C33 V01

a39001 007187290b

59101